The Bug Stops Here

Force Protection and Emerging Infectious Diseases

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Executive Summary

Throughout history, emerging and reemerging infectious disease have plagued human populations. From the earliest recorded epidemics of bubonic plague and smallpox more than 2,500 years ago to the deadly 1918 pandemic of the Spanish Flu, infectious diseases have helped to shape human history. Despite significant advances in medical research and treatment in the past century, infectious diseases remain among the leading causes of death worldwide. These diseases are appearing in places they have never been seen before or were thought to have been eradicated, are spreading faster and more frequently, and are posing an increasing global health threat that will affect national and international security in both the near- and long-term future, even affecting the success of U.S. military missions and operations.

Force health protection is an urgent priority for the Department of Defense (DOD), as increasing threats of natural outbreaks of infectious disease could seriously undermine mission readiness and success. U.S. national security might be impacted by military operations in regions with endemic and epidemic occurrences of infectious disease, where disease activity may prevent the successful completion of a mission or operation or may even result in infected soldiers carrying a contagious disease back to the United States.

Changing military doctrine and tactics call for a fresh approach to force protection. Rapid deployment of military forces, revised distribution of medical resources in theater, improved body armor, and modern combat casualty care efforts are leading to different illnesses and injuries from those seen in previous conflicts. Emerging infectious diseases in the context of urban warfare, low-intensity conflict, and the rapid movement of service members and civilians, have made a new approach to military medical support imperative. Despite improvements in combat-injury protection and wound management, disturbing trends are developing in infectious diseases in military forces.

The purpose of this paper is to review important lessons that have been learned in the past, and to revisit the older but proven principles of force protection that are in danger of being forgotten in today's technology-focused military environment. Recognizing that infectious diseases could have a significant impact on military operations, this report provides a series of case studies that analyze health threats to each regional combatant command and presents both tactical and strategic recommendations that will better prepare the entire DOD for future outbreaks of disease. These recommendations focus on procedural changes that will allow the U.S. military to regain its competitive advantage.

Line commanders may herein learn what their predecessors have learned and avoid the same fatal mistakes. Medical officers will better understand operational decision making and take the initial steps in becoming trusted advisors to line commanders. Senior policymakers will recognize that they must take action to restructure line-medical interactions to improve collaboration across bureaucratic barriers.

These recommendations largely deal with more effective management of casualties from the time of injury or illness through recovery and rehabilitation. Once implemented, they will support better identification of service members at increased risk, either from geographic location, or exposure to known or unknown hazards. Disease prevention and clinical management will be improved, civilians far removed from the combat theater will not be exposed to exotic diseases, and early detection and warning systems will enable DOD to continue to move forces worldwide without the risk of transmitting diseases. Recommendations to reduce the operational risk to DOD can be grouped into a few key areas:

- Advanced Technology Development
    - Develop rapid field tests for diseases of military operational importance.
    - Develop molecular-based assays for environmental samples.
    - Develop a topical field antibiotic or improved field wound dressing.
    - Identify promising insect repellants to provide long-term uniform protection.
    - Cost—moderate; Timeline—mid-term; Difficulty—moderate

- Improved Procedures and Policies for Expeditionary Medical Support
    - Improve infection-control practices, cohorting, and isolation in field hospitals, during medical evacuation to the United States and in U.S. hospitals.
    - Reevaluate the size, locations, and capabilities of deployed medical support.
    - Improve understanding of local disease and vector patterns.
    - Link known environmental and population data to identify high-risk areas for diseases of military operational importance.
    - Develop policies to prevent misuse of antibiotics in theater.
    - Cost—low; Timeline—short; Difficulty—easy

- Improved Civil-Military Cooperation on Epidemic Prevention and Response
    - Develop cooperative disease response and control strategies in conjunction with Federal, state, and local public health officials.
    - Link civilian and military medical research and intelligence experts to military operational needs at geographic Combatant Commands.
    - Develop a DOD/VA antibiotic susceptibility surveillance system.
    - Cost—low; Timeline—short; Difficulty—easy

- Improved Monitoring, Surveillance, and Management of Service Members.
    - Develop systems to enable tracking of service members worldwide, especially combat casualties being returned to the United States.
    - Monitor healthcare workers as a sentinel population of disease outbreaks.
    - Improve tracking of potentially infected service members by fusing disease surveillance systems with other data sources.
    - Cost—low; Timeline—short; Difficulty—easy

Introduction

> As the United States prepared for World War in 1917, experience in the cantonments, the temporary camps thrown up to train thousands of draftees, and in the sanitation of active troops showed that war is as much as ever 75% an engineering and sanitary problem, and less than 25% a military one. The wise general will do what the engineers and sanitary officers let him.
>
> Hans Zinsser, *Rats, Lice and History* [1]

Hans Zinsser, a preventive medicine consultant to the Allied Expeditionary Force in France in World War I, penned these comments to underscore the devastating effects of disease on military forces throughout history. He added that "the tricks of marching and shooting and the game called strategy constitute a minor part of war, and are only the terminal operations engaged in by those remnants of the armies which have survived the camp epidemics."[2]

Military medicine and combat casualty care have made tremendous advances in the 70 years since Zinsser's review. The typical warfighter today often experiences a lower rate of disease and non-battle injuries while deployed than in garrison. Personal protective equipment, such as body armor, provides a much greater degree of force protection in today's combat environment of urban warfare and low-intensity combat. Forward deployment of surgical teams and rapid evacuation of casualties allow injured service members to receive advanced care within just a few hours of injury.

Despite these advances in combat-injury prevention and wound management, there are some disturbing trends in the development of infectious diseases in military forces deployed overseas, suggesting that line commanders and their medical advisors may be forgetting some of the most basic elements of disease prevention. Known and unknown illnesses are emerging and spreading, both in theater and in hospitals far removed from areas of combat. The smaller and more mobile military of today accepts some operational risk due to its increased dependence on civilian transportation, supplies, and healthcare delivery, and may find its ability to move forces limited by the outbreak of a communicable disease, such as influenza or severe acute respiratory syndrome (SARS).

The purpose of this paper is to review important lessons from the past and to revisit the older but proven principles of force protection that are in danger of being forgotten in today's technology-focused military environment. Case studies are presented that focus on challenges to each geographic Combatant Command, though many of these challenges are relevant to line commanders around the world. Recommendations are provided at the joint and strategic levels, with a focus on the procedural changes that will allow the U.S. military to retain its competitive advantage.

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[1] Hans Zinsser, *Rats, Lice and History* (Boston: Little, Brown, and Company, 1935), 132.
[2] Ibid., 152.

Current and future line commanders should read this paper with the intent of learning what their predecessors have learned without repeating the mistakes that lead to loss of life and combat capability. Current and future medical officers should note how operational issues and decisions made in combat go far beyond what is learned in the classroom or in a peacetime clinic, and how they must change their approaches to protecting their forces. Senior policymakers should take action to strengthen line-medical interactions, and should force, if necessary, collaboration across service stovepipes and organizational bureaucratic barriers. Recommended solutions are not expensive—most deal with processes, procedures, communication, and coordination.

Infectious Disease Through History

The first stanzas in *The Iliad* describe a “fatal plague” that swept through the Greek army on the beaches near Troy. Homer tells us “men were dying” at the hands of a “deadly distant Archer” who

> *Cut them down in droves*
> *And the corpse fires burned on, night and day, no end in sight.*

In this epic poem, never again did the Greeks have to light corpse fires, let alone keep them going day and night. Combat with spears and swords could not kill as effectively as disease.

Throughout recorded history, emerging and reemerging infectious disease have plagued human populations. Smallpox, a deadly disease known for its high mortality rate and propensity to leave survivors with disfiguring facial and body scars, can be traced back as far as 1157 B.C. to the mummy of Pharaoh Ramses V, who many historians believe had been infected with smallpox. First described in Chinese texts in the 4th century A.D., smallpox was not eradicated until 1977, and the World Health Assembly did not officially declare the world smallpox-free until 1980.

In *The History of the Peloponnesian War,* Thucydides wrote about a “plague” that laid waste to the Athenian armies in 430 B.C., killing thousands of the population of the walled city of Athens, troops and civilians alike.[3] The first recorded outbreak of bubonic plague, known as the Plague of Justinian, occurred in 531, killing thousands of people in Constantinople, Egypt, and along the eastern Mediterranean. Nearly 800 years later, the bubonic plague, better known as “Black Death,” traveled across the European continent and Asia. Beginning in Europe in 1367, the plague epidemic continued for more than 60 years, killing as much as a quarter of the European population. Spread by the bite of infected fleas, the Black Death traveled rapidly through overcrowded cities with poor sanitation.

In the early 1800s, outbreaks of cholera, an acute intestinal infection derived from food or water contaminated with the bacterium *Vibrio cholerae,* were first recorded. In the winter of 1818-1819, cholera killed 3,000 soldiers of a 10,000 soldier British army contigent operating in India. Shortly after, outbreaks of cholera began to surface throughout Europe and Asia, leading to five epidemics between 1857 and 1923. The third such outbreak, from 1852-1860, killed more than one million Russians.[4]

One of the deadliest and best-known pandemics in the 20th century was the 1918-1919 outbreak of influenza, better known as the Spanish Flu. The deadly Spanish flu began in the spring of 1918, causing mild occurrences of flu both in the United States and across

[3] Christine A. Smith, “Plague in the Ancient World: A Study from Thucydides to Justinian.” Available online at: <http://www.loyno.edu/~history/journal/1996-7/Smith.html>.
[4] “Pandemic,” Wikipedia, 26 June 2005. Available online at: <http://en.wikipedia.org/wiki/Pandemic>.

the globe, including France, Spain, and later in England. In the fall of 1918, at the end of World War I, a second wave of outbreaks erupted around the globe, spreading along trade routes and shipping lines, and following troop movements. By the end of the pandemic, an estimated 500,000 people had died in the United States, and upwards of 50 million people had died worldwide. More people died of influenza in a single year than in four years of the Black Death Bubonic Plague from 1347-1351.[5]

The struggle to understand infectious diseases has been well documented for over 2,500 years. Scientists have studied the types of people affected, the clinical appearance of the disease in individuals, the association with war and large population movements, and possible associations with transmission vectors, such as rats, lice, mosquitoes, and water. Advances in science and technology have led to great improvements in health and have answered many questions about the bacteria, viruses, and parasites that cause disease, the vectors that transmit disease, and the body's response to disease. However, the 1969 proclamation by the U.S. Surgeon General that it was "time to close the book" on infectious disease was indeed premature.

Bacteria— A microscopic one-celled organism that is able to survive in a wide range of environments, subdivides rapidly, and is self-sufficient; depending on circumstances, may be beneficial or detrimental to the host.
Virus— An organism, smaller than bacteria, which contains genetic material——RNA or DNA——and replicates within its host for survival.
Parasite— A single or multicellular organism that lives on or in its host, which is usually a larger organism that provides physical protection and nourishment. The relationship may be beneficial or detrimental, depending on the circumstances.

Emerging Infectious Diseases

Over the past 30 years, more than three-dozen new and frightening diseases have been identified.[6] These include: the hepatitis C, Ebola, and other hemorrhagic viruses; hantaviruses; Legionnaires' disease; Nipah encephalitis; SARS; and most pervasively, the human immunodeficiency virus (HIV/AIDS).

At the same time, all-too-familiar diseases have surged. The global tuberculosis mortality rate is rising for the first time in 40 years. Malaria is returning to areas from which it had been eradicated and is spreading into new areas, such as Central Asia and Eastern Europe. Worldwide, there are now 350-500 million acute cases annually.

Infectious diseases, furthermore, have been appearing in places they have never been seen before. In 1999, the West Nile virus appeared in the New York City metropolitan area, its first appearance in North America; by the end of 2003, it had appeared in 46

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[5] Molly Billings, "The Influenza Pandemic of 1918," June 1997. Available online at: <http://www.stanford.edu/group/virus/uda/index.html.>

[6] Robin A.Weiss and Anthony J. McMichael, "Social and Environmental Risk Factors in the Emergence of Infectious Diseases," *Nature Medicine*, December 2004, vol. 10, no. 12, Supplement, S70-76.

states. Worldwide outbreaks and epidemics of diseases like dengue, meningitis, influenza, cholera, and malaria have become increasingly common. Despite remarkable progress in fighting infectious diseases, the American Society of Microbiology recently reminded a congressional committee that such diseases remain the leading cause of death worldwide and the third leading cause of death in the United States.[7] Infectious diseases are spreading faster and more frequently than ever before. The era of anti-disease optimism is ending and health communities are acknowledging defeat in the vaunted "war" on microbes.

Louis Pasteur initiated the era of optimism in the late 19th century with his proclamations that modern science could "make parasitic maladies disappear from the face of the globe."[8] Such optimism reached its peak in the two decades immediately following World War II, when antibiotics and other "wonder" drugs caught the public imagination, and health leaders thought that even tropical diseases, such as malaria, would soon be eradicated. Macfarlane Burnet, who won the 1960 Nobel Prize in medicine for his work on the human immune system, said in 1972 that "the future of infectious diseases will be very dull." Successful vaccines against smallpox and polio only furthered belief that the health threat from infectious diseases was diminishing. This optimism, it turns out, was premature.

Expectations among experts are now much more modest, especially in light of increasing antibiotic resistance of pathogens and the resistance of insect vectors to insecticides. Many microbes reproduce every 20 minutes— three generations per hour—which means that they can adapt quickly to the environment and develop resistance to medications like penicillin. Such resistance, first noticed by physicians in the early 1950s shortly after antibiotics were introduced, is now accelerating at an alarming rate.[9] According to the Centers for Disease Control and Prevention (CDC), "drug resistance of bacteria, parasites, viruses, and fungi is swiftly reversing advances of the previous 50 years."[10]

Strains of the bacteria *Staphylococcus aureus*, to cite only one of many possible examples, are now resistant to virtually every known antibiotic. At the same time, pharmaceutical researchers do not promise many new antibiotics. While several new classes of antibiotics have been discovered in the past 30 years, bacterial resistance quickly develops. Despite increasing investments in new drug discovery, the output of new drugs is dropping.[11]

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[7] The actual figure is probably higher. Mounting evidence implicates microbes in heart disease, rheumatoid arthritis, diabetes, multiple sclerosis, autism, chronic lung diseases, and other conditions and diseases previously thought to be unrelated to infection. Researchers have also documented in recent years that at least 25 percent of all kinds of cancers (but not cases of cancer) have a proven microbial involvement.

[8] Quoted in Jimmy Carter, "A Tale of Two Worlds," in *Impact: From the Frontiers of Global Health*. (Washington, DC: National Geographic, 2003), 7.

[9] DDT resistance first noticed in Greece in 1951; quickly reported in Lebanon, Saudi Arabia, and Costa Rica. Andrew Spielman and Michael D'Antonio, *Mosquito* (New York: Hyperion, 2001).

[10] Centers for Disease Control and Prevention, "Preventing Emerging Infectious Diseases: A Strategy for the 21st Century–Overview of the Updated CDC Plan," 11 September 1998. Available online at: <http://www.cdc.gov/mmwr/preview/mmwrhtml/00054779.htm>.

[11] "Despite Billions for Discoveries, Pipeline of Drugs is Far From Full," *New York Times*, 19 April 2002, C1.

Along with increasing antibiotic resistance, a number of interconnected reasons have led to the emergence and reemergence of a number of deadly infections:

- *Population and demographics*: There are now roughly 6.45 billion people in the world, and most experts believe that there will be 8 or 9 billion by 2025. Changing human demographics can lead to an increase in the occurrence of infectious disease. Population dislocation, migration, and overcrowding in cities—often without adequate clean water, sanitary facilities, and public healthcare systems—are all factors in this change.

- *International travel and commerce*: Rapid advancements in international travel allow for persons incubating diseases to move around the globe before they even realize they are sick. Furthermore, growth in international commerce and an increasingly internationalized food supply, coupled with a decrease in trade restrictions between neighboring countries, makes it easier for microbes and disease-causing insects to travel around the world in as short a time as 24 hours.

- *Economic development and changing agricultural practices*: As populations increase and animal husbandry occurs in urban and suburban locations, many more people come into contact with livestock than when farms were rural. The great increase in pig and chicken farming in China has allowed more exchange of avian and human influenza viruses.

To cite only two of the innumerable examples of how the above factors interact with each other, the current global epidemic of dengue fever began with ecological and demographic changes caused by combat in the Asian and Pacific theaters during World War II. Closer to home, the *Aedes albopictus,* or Asian tiger mosquito, which contributes to the spread of West Nile virus and other diseases, arrived in Houston in the 1970s inside worn tires that were shipped to the United States for recapping with new treads.[12] *A. albopictus* brings yet another threat to the United States, because it, along with its cousin *A. aegypti*, is also a vector for yellow fever. If travelers who are sick with yellow fever come to the southern United States in the summer, outbreaks are possible because of these two mosquito vectors.

As we try to maintain effective weapons against microbes, scientists are learning microbes do far more than simply evolve through random mutations. As part of the survival strategies that they have been developing for billions of years, bacteria and viruses can swap genes—"capturing DNA from other microbes, plants, and animals and passing this DNA to their progeny."[13] For example, genes from a virus that afflicts poultry may combine with genes from a human influenza virus subtype, causing an infection that can be spread person-to-person and against which the human immune system may have no adequate defense. This is what most worries international health

[12] Andrew Speilamn and Michael D'Antonio, *Mosquito* (New York: Hyperion, 2001), 30-45.
[13] See, for example, Bruce R. Levin, "Noninherited Resistance to Antibiotics," *Science*, September 10, 2004, vol. 305, 1578-79, and Howard Ochman, et al., "Lateral Gene Transfer and the Nature of Bacterial Innovation," *Nature*, 18 May 2000, vol. 405, pp. 299-302.

authorities as they try to contain the H5N1 avian influenza subtype now emerging in Asia, where many farmers and their families live in close proximity to the poultry and swine they raise.

This new era of emerging and reemerging diseases will continue to pose an increasing global health threat that will affect national and international security in the near- and long-term future. Infectious diseases are a major contributor to poverty and disorder. Worldwide, six infectious diseases—influenza, HIV/AIDS, intestinal infections, tuberculosis, malaria, and measles—cause nearly half of all deaths before age 44.[14] The U.S. National Intelligence Council and other government agencies warn that outbreaks of such diseases destabilize poorer nations, slow economic growth, create refugee emergencies, and impede the development of democracy, thereby sowing the seeds of military conflict.[15]

[14] Quoted in Jimmy Carter, "A Tale of Two Worlds," in *Impact: From the Frontiers of Global Health* (Washington, DC: National Geographic, 2003), 53.
[15] Central Intelligence Agency, "The Global Infectious Disease Threat and Its Implications for the United States," January 2000. Available online at: <http://www.cia.gov/cia/reports/nie/report/nie99-17d.html>.

Infectious Disease and Force Protection

Throughout history trade and conflict have played large roles in spreading disease-causing microbes. Ships in ancient Greece, for example, could travel up to a 100 miles a day, covering the entire Mediterranean in a week. With past conflict and wars, it was almost always the case that soldiers were more likely to die from disease than from combat-related injuries. Military commanders have long struggled with the decimation of their fighting forces because of disease. Crowding, inadequate food and rest, mixing of soldiers from urban and rural backgrounds, and the difficulty in balancing prevention costs with the unnecessary loss of combat troops to disease perplex line commanders to this day.

George Washington, facing the British troops that occupied Boston shortly after the Battle of Bunker Hill in 1775, reported in writing to the Continental Congress that smallpox was his "most dangerous enemy."[16] During the Valley Forge winter of 1778-79, Washington decided that all of his men had to be inoculated against smallpox, even though as a direct result of the procedure about two percent of them would die.[17] [18] This decision kept his fighting forces effective when smallpox later incapacitated and killed British soldiers before and during crucial battles.

During the Spanish-American war, only a little more than a century ago, commanders did not feel it was their responsibility to prevent or combat diarrhea, even when it laid waste to their troops; only rarely were orders given to move mess areas away from latrines, a simple action that would have significantly decreased the occurrence of disease.[19]

> "Though the percentage actually on the sick list never got above 20, there was less than 50% who were fit for any kind of work."
> Colonel Theodore Roosevelt on the Battle of Santiago, 1898.
>
> Source: R. Major, *Fatal Partners: War and Disease*. (New York: Doubleday, Doran, and Company, 1941)

[16] Donald R. Hopkins, *Princes and Peasants: Smallpox in History* (Chicago: University of Chicago Press, 1983), 258.
[17] Elizabeth A. Fenn, *Pox Americana: The Great Smallpox Epidemic of 1775-1782* (New York: Hill and Wang, 2001), 93.
[18] The smallpox virus is *Variola major*, so inoculation against smallpox is called variolation. In 1796, Edward Jenner discovered that inoculation with the cowpox virus (V*accinia*) provided cross protection against smallpox. Louis Pasteur later adopted the word 'vaccination' for immunization against any disease.
[19] "History of Military Medicine: Lessons from Today's Vaccines," CTNSP/NDU Senior Level Seminar Series, Vaccines Workshop, National Defense University, 17 March 2005.

The importance of other anti-infectious disease efforts has become a lesson that military commanders have to learn over and over again. On Guadalcanal, in late 1942, as control of the South Pacific island hung in the balance, and diseases such as malaria reduced some 200-man rifle companies to 65 men,[20] a top Marine officer insisted, "We came here to kill Japanese, not mosquitoes."

Fortunately, his commander, General Douglas Macarthur, thought otherwise. From Pearl Harbor to the summer of 1943, malaria caused eight U.S. casualties for each one caused by the Japanese military, and six out of ten malaria-carrying mosquitoes came from man-made sources like tire tracks.[21] Then, thanks to stringent mosquito control efforts that had General Macarthur's direct, personal support, the malaria rate dropped by 95 percent. A June 1944 press release from Pacific headquarters reported that Macarthur had won "one of the greatest victories—in the Southwest Pacific Areas—a victory of Science and discipline over the anopheles mosquito."[22]

"The mosquito is little but has bugs in her spittle.
Repellents and spray will keep her away!

Antimalaria jingle broadcast on the "Mosquito Network" to Allied forces in the World War II Pacific theater. A monthly pin-up calendar and Sunday cartoon used "Mosquito Moe" and "Anopheles Ann" to remind troops to roll down their sleeves, use repellents, and take other precautions. The "Atabrine Cocktail Hour" of recorded music always began with a "commercial" urging malaria control. Atabrine was the daily medication taken to protect from malaria infections.

Source: Leon Warshaw, *Malaria: the Biography of a Killer* (New York: Rinehart & Company, 1949), 298.

Preventable Disease and Non-battle Injuries

In today's rapidly changing disease threat environment, it is crucial to anticipate likely risks and to rapidly develop and implement preventive countermeasures to enable warfighters to survive these threats. Such health threats rarely come to the attention of the public but are vitally important, nonetheless, because of their detrimental impact on combat effectiveness. Prevention and response to such threats deserves in-depth analysis during combat operations and should not be delayed until after the conflict, when researchers can pore over disease and injury data after troops have returned home. The U.S. military publicly announces the number of uniformed personnel killed in action, the number of "non-hostile deaths," and the number wounded. The low numbers who actually get sick in theater and the numbers of service members who are so sick that they

[20] Robert T. Joy, "Malaria in American Troops in the South and Southwest Pacific in World War II," *Medical History*, 1999, 43: 196.
[21] Edmund Russell, *War and Nature* (Cambridge, U.K.: Cambridge University Press, 2001), 114.
[22] Ibid., 117.

must be airlifted out of the war zone, are rarely identified during military operations, even though the military preventive medicine and public health community has made considerable progress over the past 20 years in preventing disease and maintaining the health of each service member.

Historically, disease and non-battle injury (DNBI) rates have rivaled those from battle injuries.[23] [24] Aggressive commander attention to reduce preventable injuries has reversed this pattern since World War II. Non-battle injury rates now account for a much smaller proportion of DNBI—one fourth of the combined DNBI total, down from half just 50 years ago.

Comparable disease and non-battle injury data are not available from earlier conflicts because of differences in category definitions, completion of data, and other methodological issues. Data from the Crimean War in 1854 to 1856, one of the earliest wars in which accurate records were kept, show how much more destructive disease was than combat.[25] The opposing armies suffered almost equally from diarrhea and dysentery caused by cholera and other organisms, epidemic typhus (an infection transmitted from man to man by the body louse, especially common in refugee camps and during war, famine, and disasters), and other diseases.[26] The French and Russian armies lost 50,000 and 37,000 men, respectively, to disease; they lost 20,000 and 38,000 to wounds.

Figure 1

Crimean War, 1854-1856

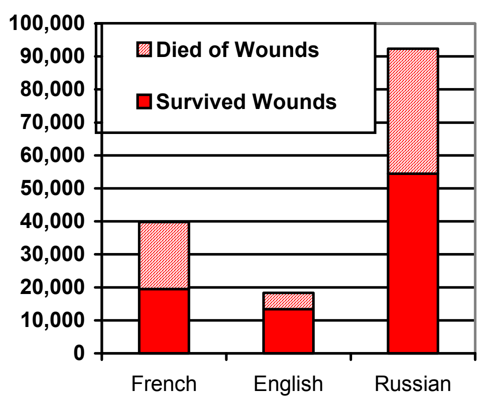


Figure 2

Crimean War, 1854-1856

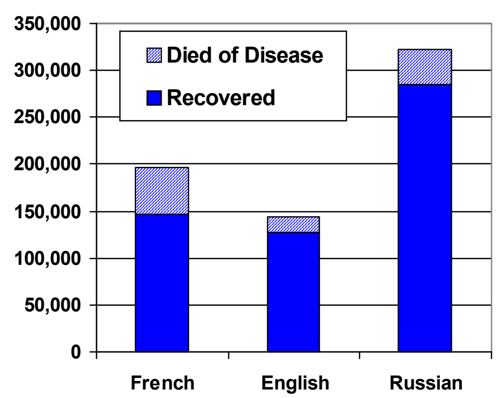


Figure 1 & 2— Hans Zinsser, *Rats, Lice and History* (Boston: Little, Brown, and Company, 1935).

[23] Non-battle injuries include non-combat related motor vehicle accidents, training injuries, and recreational injuries.
[24] Institute of Medicine, *Strategies to Protect the Health of Deployed U.S. Forces* (National Academy Press, 1999), 23-24.
[25] Zinsser, 165.
[26] A notable exception was the lower rates of disease and death from combat wounds in the English forces, probably because of the efforts of Florence Nightingale, who introduced nursing care into combat casualty care.

Data collected during U.S. conflicts are consistent with these findings. Deaths due to non-battle causes exceeded those due to battle from the Revolutionary War until World War II.

Figure 3

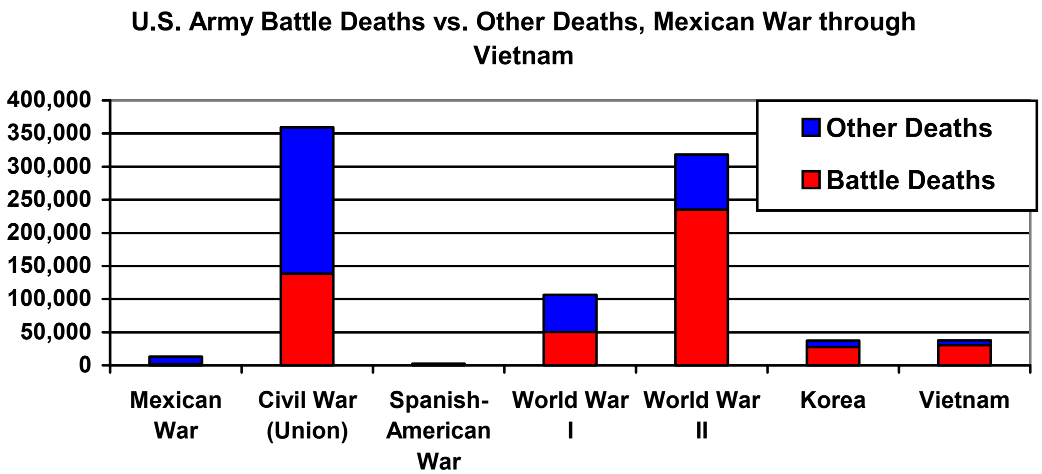
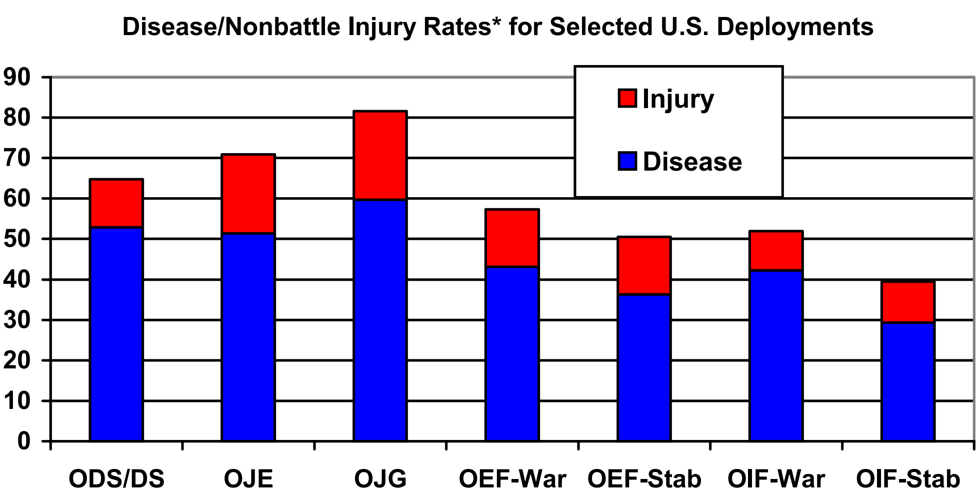


Figure 3—James James, Alyce Frelin, and Robert Jeffery, *Disease and Nonbattle Injury Rates and Military Medicine*, Medical Bulletin of the U.S. Army, Europe 39 (8):17-27, August 1982.

Figure 4



***Incidence rates per 1000 service members per week**
ODS/DS— Operation *Desert Shield/Desert Storm* 1990-1991
OJE— Operation *Joint Endeavor*— Balkans '95-96
OJG— Operation *Joint Guard*— Balkans '97-98
OEF/OIF— Operation *Enduring Freedom* and Operation *Iraqi Freedom*

- **War phase—15 Mar 03— 3 May 03**
- **Stabilization phase— 4 May 03— 26 Mar 05**

Sources: Jose Sanchez, et al, Health Assessment of U.S. Military Personnel Deployed to Bosnia-Herzegovina for Operation Joint Endeavor, *Military Medicine* 166 (2001):470-474; Kelly McKee, et al, Disease and Nonbattle Injury among United States Soldiers Deployed in Bosnia-Herzegovina during 1997: Summary Primary Care Statistics for Operation Joint Guard, *Military Medicine* 163 (1998): 733-741; Air Force Institute for Operational Health, "Historic and Recent DNBI Rates", 4 April 2005.

Much of this improvement has been due to the general decrease in many infectious diseases over the past century, as well as improved preventive and medical treatment measures, but closer examination indicates that there continues to be troop loss due to preventable illness and injuries.

As the data from the past decade demonstrate, cases of diseases and non-battle injuries have fallen to record lows in recent force deployments. Greatly improved tracking and recording of types of illnesses and non-battle injuries have allowed preventive efforts to be targeted at the point where illnesses and injuries can best be prevented, but all this laudable effort is at risk if military line commanders and their medical advisors allow the emphasis on force protection and anticipating emerging disease patterns to decay.

Force Protection Measures

For commanders and warfighters at all levels, responsible preparation for military operations and force health protection requires an understanding of basic disease concepts, risks, and trends, and what threats can be reasonably anticipated in any geographic area. Scientific progress in molecular biology, biotechnology, and other, new fields has led to great progress in our understanding of disease, in the medical capabilities at our disposal, and just as essentially, in commander priorities.

Control methods against most illnesses are notoriously low-tech and do not fit the "Warfighter of the 21st Century" stereotype. While hand washing, head-to-toe sleeping arrangements, "sneeze" barriers between beds, improved air exchanges, and air sterilization with ultraviolet light are all proven to reduce respiratory illnesses in service members in-garrison, these measures are obviously not as high a priority during combat operations as body armor and night vision goggles, and often are not technically feasible in the field.[27] There are, however, many measures that can and should be taken in the field to protect warfighters from avoidable infectious disease threats.

Once the decision has been made to engage in a military operation, commanders should first define the mission, resources, and parameters for the operation, then task medical staff to gather and examine pre-engagement medical and environmental intelligence and provide advice for protection against any threats. This can be as simple as asking questions: Is malaria in the area, and if so, what type? What prophylactic combination of drugs works best against it? What preventive countermeasures, such as mosquito repellant or bed nets, will warfighters need? More complex questions may include: Do other infectious diseases put the mission at risk? Are there geographic, environmental, climatic, vector, or population factors requiring risk management efforts? Soon, remote sensing of global ocean temperatures may make it possible to predict rain and subsequent mosquito levels with some accuracy.[28] Satellite imagery also may help identify potential geographic, environmental, and vector-borne disease risks.

Trusted professional relationships between commanders and their medical experts are essential so that the best scientific advice may be shared in an operationally relevant context. The field environment is no place for a civilian physician who does not understand the operational military culture, warfighting mission, and risk management process. Combat casualty care in Vietnam required a degree of expertise that was not developed in a civilian practice in the United States. New surgeons arriving in Vietnam were attached to experienced teams for orientation, and they learned new techniques in

[27] Terrence Lee, et al, "Selected Nonvaccine Interventions to Prevent Infectious Acute Respiratory Disease," *American Journal of Preventive Medicine,* April 2005*,* 28: 305-316.
[28] See, for example, D.A. Focks, et al., "Transmission Thresholds for Dengue in Terms of *Aedes Aegypti* Pupae per Person With Discussion of Their Utility in Source Reduction Efforts," *American Journal of Tropical Medicine and Hygiene*, January 2000, 62: 11-18.

the operating room.[29] The effective Joint Task Force Surgeon will have the best scientific solutions to protect combat forces from preventable threats and will know which of these are possible, given local operational requirements. He or she must succinctly present to the line commander those threats that may impact mission completion and the available preventive countermeasures, and must clearly state the risks and benefits of the various courses of action.

Once the responsible line commander selects a course of action, the surgeon continues to assist subordinate commanders as they implement countermeasures, and monitors for unanticipated events that may call for rapid responses. If the unit medical officer is not an effective operational advisor and is unable to provide appropriate courses of action to protect warfighters, the unit commander must relieve him or her and find a trusted, forward-leaning medical officer who can be relied upon to provide the best available, operationally relevant, medical advice to protect the forces. If, on the other hand, the unit commander does not request, understand, accept, or implement operationally relevant, preventive medical advice, then it is appropriate to elevate the issues to a higher command level. British Field Marshall Sir William Slim, who rebounded from a catastrophic loss in Burma in 1942 to win an overwhelming victory over the Japanese in 1944 and 1945, took aggressive action when his line commanders failed to implement his command guidance—he relieved them from command. Concerning compliance with the requirement to take a daily mepacrine pill, the medication taken to prevent malaria, Slim had surprise checks of whole units. "If the overall result was less than ninety-five per cent positive, I sacked the commanding officer. I only had to sack three; by then the rest had got my meaning."[30]

Training and education are essential, especially when medicines, such as those that combat malaria, must be taken for weeks after an individual's last exposure to disease-carrying mosquitoes. The malaria-causing parasite can live dormant for months and even years in an infected individual's liver without causing symptoms. Failure to take prescribed prophylactics until the threat of disease has been eradicated can allow parasites to multiply and cause disease and death to troops even after they return from overseas deployment. Discipline is crucial to assure that troops comply with command guidance and direction to take medications, use personal protective equipment, such as bed nets and insect repellant, and use common-sense protection, such as sleeping in uniforms that cover the skin rather than leaving skin exposed to biting insects. The medical officer has no role in such command discipline; only the unit commander can enforce compliance.

Troop movement becomes more complicated if the potential deployment site involves areas designated by the CDC as having "repeated experience with outbreaks of diseases once thought to be archaic or obscure." Included in recent years are outbreaks of plague in India and leptospirosis in Nicaragua and the Malaysian portions of Borneo. In late 2004–early 2005, reports emerged that pneumonic plague had infected workers at a

[29] Spurgeon Neel, *Medical Support of the U.S. Army in Vietnam, 1965-1970* (Washington, DC: Department of the Army, 1973).
[30] Sir William Slim, *Defeat Into Victory* (London: Cassell and Company, 1956), 180.

diamond mine in the Congo. Microbes that cause this plague are airborne, more virulent and dangerous than the bubonic plague, and spread by the same kind of rat-borne fleas that were responsible for the Black Death epidemics in the Middle Ages.[31]

> Plague is an infection caused by the bacterium *Yersinia pestis*. The disease usually presents in three clinical forms in humans: bubonic, pneumonic, and septicemic. Bubonic plague was the cause of the Black Death epidemics that wiped out one quarter of the population of Europe in the Middle Ages. Bubonic plague is transmitted by infected fleas that infest rats and has historically spread quickly in urban and suburban areas with poor sanitation systems where plague-infected rats flourish. The infection is transmitted when a person is bitten by the infected flea, and the plague bacterium migrates to the lymph nodes in the arm pits or the groin, where it causes the classic swollen buboes that give the disease its name. The infection then spreads throughout the body via the bloodstream. It can be transmitted from person to person once it reaches the lungs. Pneumonic plague occurs when the bacteria are inhaled in an aerosol form when a person with pneumonic plague coughs (or when the bacteria are intentionally released in a bioterrorism attack). This route of infection causes illness within one to two days and quickly leads to death, unless promptly treated with antibiotics.

> Leptospirosis is a disease caused by the bacterium *Leptospira interrogans*, found in the tissues and urine of infected dogs, swine, and rodents. It is transmitted to man upon contact with infected tissues, or more commonly by contact with contaminated water. It causes fever, meningitis, and liver and kidney infections and is common in the Southern United States and in the tropics. Its military operational association is obvious, since one of its names is Fort Bragg fever. It is also known as European swamp fever, mud fever, and swineherd disease. It is easily treated with antibiotics, once a correct diagnosis is made.

[31] "Pneumonic Plague Seen in Congo Outbreak," *Washington Post*, 15 February 2005, A19.

Commander's Pre-Deployment Operational Checklist[32]

Issue	Office of Primary Responsibility	Information Source
What are the known infectious disease threats?	SG	CDC, WHO, Armed Forces Medical Intelligence Center
What is the civilian experience with infectious diseases in this area?	SG	WHO
What are the environmental hazards in this area?	J2, SG	NOAA, USGS, AFMIC
Are my troops adequately protected with vaccines?	SG	CDC, AFMIC
Do my troops need to take any medications to protect from malaria?	SG	CDC, AFMIC
Do I have sufficient personal protective equipment (bed nets, DEET insect repellant, permethrin repellant to treat uniforms) to protect from insects?	J4, SG	
Are there any environmental control measures that will reduce exposure risks to my troops?	J2, J4, SG	NOAA, USDA, AFMIC
Have I issued operational orders to my line commanders to assure troops use personal protective equipment while exposed?	J3, Chief of Staff	
Have I established an inspection system to see that my preventive medicine orders are obeyed?	J3, Chief of Staff	
Are environmental and medical threat surveillance systems in place to monitor changes in environmental and disease threats?	J2, J4, SG	
Are systems in place to detect any changes in infectious diseases in nearby civilian populations?	POLAD, SG	Dept of State, WHO, CDC
Is there a risk of unexpected civilian population displacement that may inadvertently expose my troops to increased infectious disease risk?	J2, SG, POLAD	Dept of State, NGOs, UNHCR
Are there additional precautions I must take to protect against such risks?	J2, SG	
Are medical surveillance systems in place to monitor, detect, and warn of any unexpected disease occurrence in my troops?	J4, SG	

[32] Definitions: The Joint Staff Directorates : J1— Manpower and Personnel; J2—Intelligence; J3—Operations; J4— Logistics; J5— Strategic Plans and Policy; J6— Command, Control, Communications & Computer System; J7— Operational Plans and Interoperability; J8— Force Structure and Resources and Assessment; POLAD – Political Advisor; SG— Command Surgeon; CDC— Centers for Disease Control and Prevention; WHO— World Health Organization; AFMIC— Armed Forces Medical Intelligence Center; NOAA— National Oceanic & Atmospheric Administration; USDA— United States Department of Agriculture; USGS— U.S. Geological Survey; NGO— Non-Government Organization; UNHCR—United Nations High Commissioner for Refugees.

International agencies, such as the World Health Organization (WHO) have regional rapid response networks—trained personnel, protective equipment, and data analysis capability—capable of investigating and, if necessary, managing suspected cases of infectious disease if the host nation permits. Although these agencies work closely with the CDC, their close cooperation with a military operation is not assured.[33] DOD partially addresses this shortfall by providing deployable laboratory and diagnostics capability for each mission to an area where known infectious diseases are prevalent.

Post-combat capacity to diagnose and treat diseases is another shortcoming. Even for common and familiar infections like malaria, symptoms may not appear until weeks or months after exposure. Fewer than a dozen returned travelers now die of malaria in the United States each year, but more than 1,000 get sick with malaria that is often not diagnosed until they are near death. Symptoms from a virus, such as hepatitis C, may not appear for decades, so commanders may never know the health consequences of particular operations.[34] Zinsser observed that the average professional officer thinks of the military doctor as an "unwillingly tolerated noncombatant who takes sick call, gives cathartic pills, makes transportation trouble, complicates tactical plans, and causes the water to smell bad. He is useful after an action to remove the debris, but otherwise he is a positive nuisance."[35] Historical experience shows otherwise—the commander ignores medical advice at his own peril.

Good medical intelligence is not enough to reduce the effect of infectious disease on warfighters. The ability to fight at night has become a significant U.S. tactical advantage, yet nighttime is when many disease-carrying mosquitoes are most active. Such mosquitoes and other insects can also affect urban fighting during the day. There is no known way to prevent dengue fever—known as "breakbone fever" because of the debilitating pain it causes—other than to avoid being bitten by *A. aegypti* mosquitoes that carry the dengue-causing virus. These mosquitoes, which are most active during daylight hours, have adapted well not only to cities, but also to the damage caused by urban warfare. In the wild, *A. aegypti* breed in small bodies of water, such as the few raindrops that may accumulate in a broken bamboo shoot. In cities, they thrive in anything in which water can collect, like broken dishes, pieces of glass, and abandoned tires.

The tendency today is to believe that infectious diseases are a thing of the past, thanks to advances in science and technology. However, infectious diseases have a huge—and perhaps a growing—role in military affairs. Indeed, emerging infectious diseases seem to permeate every aspect of military operations, from the broad circumstances that make the use of armed forces necessary, to the detailed decisions made by individual warfighters during an action, to new processes, procedures, and technologies that must be developed to manage combat casualties and diseases that may be acquired outside the United States.

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[33] Centers for Disease Control and Prevention, "Protecting the Nation's Health in an Era of Globalization: CDC's Global Infectious Disease Strategy," 2002. Available online at: <http://www.cdc.gov/globalidplan/global_id_plan.pdf>.

[34] See, for example, , Sandt L. St John TM, "The hepatitis C Crisis," *Ethnicity and Disease,* Spring 2005, 15 (2 Suppl 2):S52-7.

[35] Hans Zinsser, *Rats, Lice and History* (Boston: Little, Brown, and Company, 1935), 152.

Force protection and freedom of troop movement may be directly curtailed by emerging infectious diseases. Geographic disease patterns and operational requirements may put military personnel at such risk that combat operations may need to be cut short. The next section of the paper identifies realistic health threats in relation to the Regional Combatant Commands, where the force protection issue is most relevant and provides recommendations for addressing these threats, not only for the Combatant Commands, but for the entire DOD.

Emerging Infectious Diseases and Regional Combatant Commands

United States Central Command (CENTCOM)

The CENTCOM area of responsibility (AOR) has multiple sites where U.S. and coalition military forces will be in place for a prolonged period of time. Operation *Enduring Freedom* and Operation *Iraqi Freedom* (OEF/OIF) both required rapid development of forward operating locations to support combat operations. As operational requirements stabilize and mobility becomes less of a priority, actions should be taken to improve troop protection from emerging infectious disease risks. The following two case studies show how infections with *Acinetobacter baumannii* and *Leishmania spp.* in warfighters calls for a reevaluation of in-theater distribution of medical resources given the constraint of minimizing the footprint of combat support personnel and assets in country. Such resource constraints, including supplies, equipment, personnel, and facilities, require anticipation of, and planning for, possible alternatives. These case studies provide examples of emerging infectious threats and the resulting operational impacts, and offer opportunities to make substantive changes to military medical doctrine, plans, and policies to improve the combat effectiveness of today's lighter, faster forces.

Case Study I—Acinetobacter: Urban Warfare, Low-Intensity Conflict, and Emerging Infections

Changing ground combat tactics, equipment, and conditions have led to different patterns of wounds in U.S. warfighters. Combat wounds during World War II and the Vietnam War were often high-velocity bullet wounds and low- velocity grenade fragment wounds to the chest, with injuries that were quickly fatal. Body armor developed, improved, and deployed over the past 30 years has saved many lives, and has led to different patterns of wounds in the survivors. In Somalia in 1993, soldiers wore heavy body armor that shielded the chest from many direct wounds, so a higher percentage of injuries and deaths resulted from pelvis and extremity wounds.[36] Since then, body armor has become lighter and has provided additional protection to the abdomen, groin, and throat, so the numbers of immediately fatal injuries from both bullets and grenade fragments have decreased.

Compared to full-scale field combat, like that of World War II and Vietnam, low-intensity conflict in the urban environment leads to more use of close-in weapons, for example, rifles used by snipers, explosive charges, such as improvised explosive devices (IEDs), and rocket-propelled grenades. These weapons create a much smaller lethal zone

[36] Robert L. Mabry, et al. "United States Army Rangers in Somalia: An Analysis of Combat Casualties on an Urban Battlefield," *Journal of Trauma,* September 2000, 49 (3): 515-52.

that may be survivable if the warfighter is properly protected. Low-intensity military conflict between the Israeli Defense Forces and the Palestinian Armed Forces during the Al-Aqsa Intifada beginning in September 2000 showed combat injury patterns where 75 percent of wounds were to the extremities, head, face, and neck, thanks to the use of Kevlar helmets and ceramic body armor.[37] Low-intensity conflict in Iraq, such as the recent urban offensives in Fallujah and Al-Anbar province, show similar injury patterns, but injury patterns are changing somewhat in the stabilization phase of the conflict. During the stabilization and reconstruction period in Iraq, patrolling forces are more likely to be ambushed by IEDs, such as suicide bombers in cars. The resulting low-intensity-conflict injury pattern is reflected in a higher proportion of extremity wounds.

Figure 5

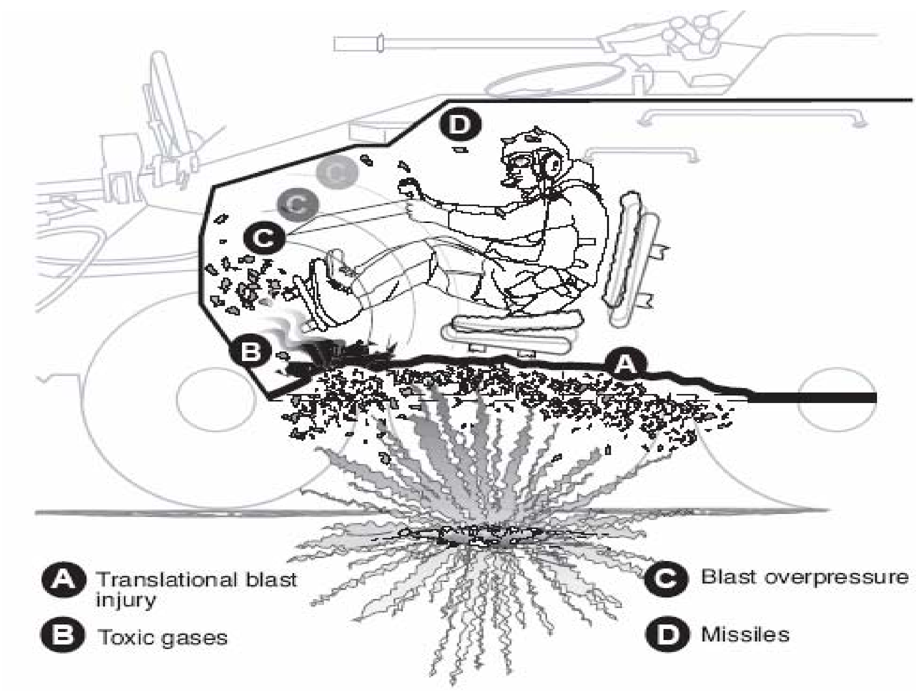


Figure 5 demonstrates the complex injuries caused by IEDs in urban warfare. The armored vehicle often provides enough protection so the service member survives the initial blast, but multiple types of injuries resulting from other mechanisms require aggressive surgical and medical management.

Source: David Lounsbury and Ronald Bellemy, *Emergency War Surgery,* 3rd Edition (Washington, DC: Borden Institute, 2003).

[37] Dror Lakstein and Amir Blumenfeld, "Israeli Army Casualties in the Second Palestinian Uprising," *Military Medicine,* May 2005, 170: 427-430.

Figure 6

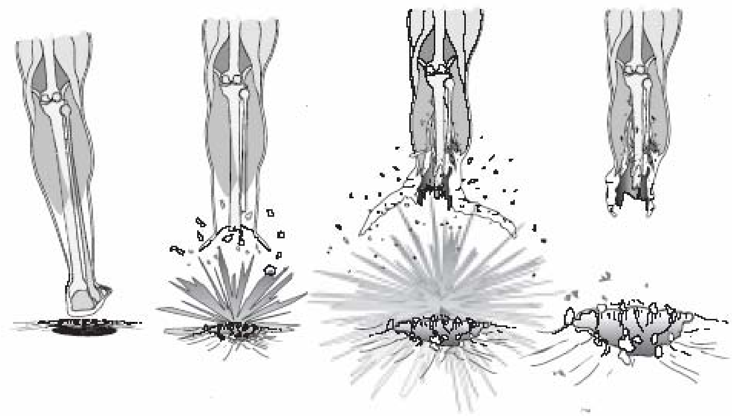


Figure 6 demonstrates the mechanism of injury and severe lower extremity damage from a land mine or from a small IED. The vital structures within the chest and abdomen are relatively shielded by body armor and by the rest of the service member's body, so prompt control of bleeding by a combat medic enables many warfighters to survive these injuries.

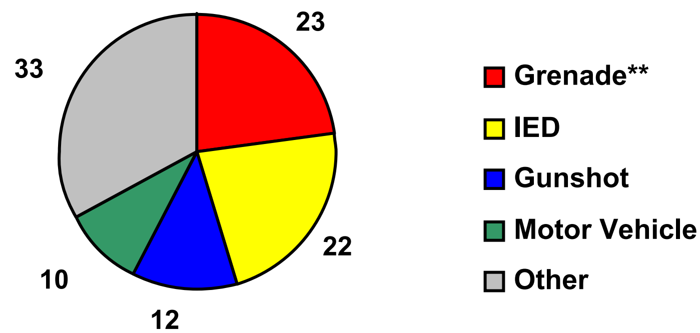
Source: David Lounsbury and Ronald Bellemy, *Emergency War Surgery, 3rd Edition* (Washington, DC: Borden Institute, 2003).

The real success of body armor is in the wounds prevented, because many explosive fragments are deflected by the armor and never cause any wounds. In urban warfare and low-intensity conflict, however, low-velocity fragments are injuring unprotected areas of the face and extremities, because the vital structures within the chest and pelvis are relatively protected. Thanks to better personal protection, warfighters are surviving attacks that would have been fatal in previous conflicts, but this creates an emerging issue of infections caused by microorganisms.

Warfighters in field combat conditions carry a heavy amount of bacterial contamination on their clothing and skin, and any wound allows this contamination to enter the body. Delays in resuscitation, evacuation, and surgical wound care increase the chance that this contamination will develop into infection, because the longer bacteria are in a wound with poor blood supply and dead tissue, the more likely a serious infection will develop.[38]

[38] Rodney Peyton, Carl Griffiths, and Daniel Rignault, "Terrorist Injury," in *Ballistic Trauma: Clinical Relevance in Peace and War*, James M. Ryan, Ed. (Oxford University Press, 1997), 277-282.

Figure 7
Mechanism of Injury*
OEF/OIF Battle and Non-Battle Injuries



* Casualties may have more than one mechanism of injury.
**Includes fragmentation grenades, mortars, and bombs.

Figure 7 indicates that 45 percent of the casualties in the first two years of OEF and OIF were injured by munitions that produced low-velocity fragments: IEDs, grenades, mortars, and bombs. These fragments cause multiple penetrating wounds that damage extensive amounts of tissue and introduce much more contamination than a single gunshot wound.

Source: Joint Theater Trauma Registry Report, 13 April 2005.

Changing enemy combat tactics calls for changing the tactics not only of coalition forces, but also of those responsible for force protection, and for managing these changing casualty patterns. Military combat casualty care is adapting to these shifting injury forms, but the logistical support, medical evacuation, and referral healthcare structure must adapt as well. The U.S. military moved to a much smaller in-theater footprint after the success of Operation *Desert Storm* in 1991, but this shift has not come without costs. The focus of this case study is to describe some of the effects that this change in doctrine has had on combat casualty care and to provide recommendations as to how some of these newly identified deficiencies could be addressed.

Many service members who were severely injured in Iraq are returning to the United States with bloodstream infections caused by the bacterium *Acinetobacter baumannii,* an organism found in soil and water in many parts of the world known to cause pneumonia and bloodstream infections. An isolated case of this infection might not be an issue, but the emerging pattern is one of a cluster of infections among a high proportion of personnel in an identifiable group and is a clinical issue that needs resolution. Moreover, ongoing transformation of the military to a light-weight, highly mobile, combat force with a small support infrastructure that has limited immediate medical support suggests that such types of infections are just the tip of the iceberg for military medics. Military medical doctrine has changed from providing definitive treatment in theater with large

field hospitals to rapid stabilization as close to the fighting as possible, with rapid aeromedical evacuation out of the theater of combat. For casualties from Iraq and Afghanistan, for example, additional surgical care is provided en route at Landstuhl Regional Medical Center in Germany. These casualties are then returned to the United States for definitive surgery and rehabilitation. This concept of operations is not ideal for wound management because complete initial management of combat injuries is not always possible and in-theater diagnostics and treatment are limited by resources. One consequence is a growing number of infections with *A. baumannii*.

Current doctrine for combat casualty care focuses on rapid stabilization of casualties by Forward Surgical Teams, where the emphasis is on controlling bleeding and rapid aeromedical evacuation. This practice results in minimal debridement of contaminated wounds, which allows the development of infection, putrefaction, gas gangrene, and bloodstream infections. The cornerstone of combat casualty care is debridement within six hours so that foreign bodies—dirt, clothing, debris, bone splinters—and obviously dead tissue are removed before serious tissue infections can develop.[39] During the Vietnam conflict, service members underwent full debridement by a surgeon in a hospital close to the area of combat, sometimes for five to seven days, until the wounds were clean. According to one study, the mean time of hospitalization in Vietnam was 9.2 days.[40] In Iraq and Afghanistan, wounded service members are being evacuated in as little as 12 hours; the fact that sand from Iraq is still being washed out of wounds in Germany and in Washington, D.C suggests that debridement in theater is inadequate. While rapid stabilization and transport policy allows lives to be saved with a smaller military medical footprint in theater, under-debridement of combat wounds appears to be shifting the burden of medical care to portions of the military and civilian healthcare system not yet prepared for the added precautions necessary to prevent infection.

The result is that wounded service members who may be harboring dangerous infections are being returned to the United States to medical treatment facilities (MTFs) that are unprepared for them. In the combat theater, these casualties are a well defined group in a setting focusing on combat casualty care, but once they return to the United States, they become a group requiring special monitoring and handling, because they are mixed with other DOD beneficiaries receiving general medical and surgical care in military MTFs. Many of these other beneficiaries are seriously ill retirees with significant medical conditions, such as diabetes, pulmonary disease, and other diseases that compromise their ability to fight off infection. Effects of this mixing of recent combat casualties from Iraq with other DOD beneficiaries have been considerable. There have been at least 43 episodes of person-to-person transmission of *A. baumannii* at Walter Reed Army Medical Center in Washington D.C., leading to deaths of at least three elderly patients who were infected while hospitalized at Walter Reed. There have been two cases of person-to-person transmission at the National Naval Medical Center in Bethesda, Maryland, with

[39] Simon Mellor, Charles Easmon, and Jay P. Sanford, "Wound Contamination and Antibiotics," in *Ballistic Trauma: Clinical Relevance in Peace and War*, James M. Ryan, Ed. (Oxford University Press, 1997), 61-71.

[40] Elliot Jacob and Jean Setterstrom, "Infection in War Wounds: Experience in Recent Military Conflicts and Future Considerations," *Military Medicine*, June 1989, 154 (6): 311-315.

the death of one elderly patient. There have also been outbreaks at a Combat Support Hospital in Baghdad, the U.S. Navy Hospital Ship USNS *Comfort*, and the U.S. Army Landstuhl Regional Medical Center in Germany, where another elderly patient died from an infection contracted in the intensive care unit from a wounded solder from Iraq. Additional cases have been identified at Brooke Army Medical Center in San Antonio, Texas.[41] The infections with *A. baumannii* initiated in-theater are thus causing medical concerns in a much broader medical setting.

A significant complicating factor for *A. baumannii* and many other wound-infecting organisms is antibiotic resistance. The *A. baumannii* bacterium is readily divided into two main groups: one group that is sensitive to many antibiotics but can rapidly develop resistance when exposed to antibiotics, and another group that is already resistant to most antibiotics. Regardless of grouping, these bacteria represent a challenge to treatment with conventional antibiotics. The *A. baumannii* observed in returning U.S. service members is already resistant to multiple antibiotics and requires treatment with an extremely expensive antibiotic (Primaxin) that is usually reserved for rare infections. Pharmacy spending on Primaxin increased from $43,000 to $226,000 in the first two years of OEF/OIF at the two military medical centers treating most of these combat casualties.[42]

Figure 8

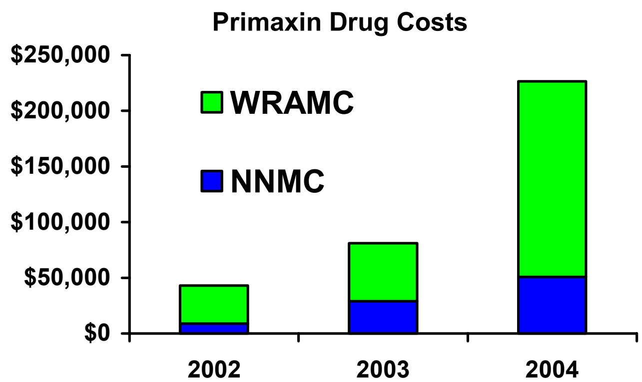


Figure 8: Accurate treatment costs for combat casualties are very hard to determine. Military medical treatment facilities do not have data systems that support easy identification of patients admitted from various conflicts, or for the routine or extraordinary costs associated with treating them. Costs for the gowns, masks, and gloves necessary to maintain strict hospital infection could only be estimated. During the four year period from 2001-2005, pharmacy data systems changed in two facilities, so actual costs for these antibiotics could only be estimated based on average costs and antibiotic usage before 2002 compared to costs and usage in 2005. The authors greatly appreciate the efforts made by Pharmacy, Medical Supply, Safety, Infection Control, and Infectious Diseases personnel at Walter Reed Army Medical Center, National Naval Medical Center, and Brooke Army Medical Center.

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[41] Centers for Disease Control and Prevention, *Morbidity and Mortality Weekly Report*, 19 November 2004, vol. 53 (45): 1063-1066.
[42] Major Kimberly Moran, Walter Reed Army Medical Center; Lieutenant Commander Kyle Petersen, National Naval Medical Center, personal communication, 09 August 2005.

A. baumannii is a known pathogen in the United States, but in the patient population represented by service personnel, these unusual presentation and transmission patterns are cause for concern. While the bacterium is known to cause hospital-acquired cases of pneumonia and bloodstream infections in the United States, it is usually seen in severely ill patients whose immune systems are compromised. Despite being the cause of 50 percent of wound infections in Vietnam casualties, it was not seen during the Persian Gulf War in 1990-1991. Some speculate that the cause for this is that there were so few casualties in Operation *Desert Storm*, and urban warfare was not a factor, so injury patterns and combat casualty care practices did not create the right environment for *A. baumannii* to become noticeable. It was the cause, however, of 31 percent of hospital-acquired infections in earthquake victims in Turkey in 1999, and at least eight cases of hospital-acquired infections in Perth, Australia, among 29 of the persons injured in the October 2000 Bali bombing.[43] It therefore represents an opportunistic pathogen that, once established in a location or environment, can become a significant infectious agent with problematic outcome and treatment concerns.

Military epidemiological investigations to date suggest that most infections with *A. baumannii* are associated with severely injured soldiers who are resuscitated at one of the U.S. Army Combat Support Hospitals in or around Baghdad.[44] The bacterium has been detected on hospital equipment in operating rooms and intensive care units in several deployed field hospitals. Genetic fingerprinting of organisms collected from 58 patients has identified five distinct clones that match the organisms collected from the field hospitals, suggesting that the hospitals may be the underlying source of the infections. As previously stated, antibiotic resistance is a serious problem with *A. baumannii* infections. The only effective antibiotics (Primaxin and Polymyxin B) are used only rarely because of their toxicity and cost, and to preserve their effectiveness in treating life-threatening infections.

The mechanism of colonization, infection, and person-to-person transmission are not yet understood.[45] The source of the initial infection may be from soil or other environmental sources of contamination, or may result from continued transmission within field surgical hospitals in Iraq. Transmission seems to occur more frequently in combat casualties with severe soft-tissue and orthopedic injuries, but it is unknown whether transmission occurs during the initial trauma, following resuscitation, during surgery, or while Soldiers and Marines with blood stream infections are recovering at Walter Reed Army Medical Center and the National Naval Medical Center. The fact that it is not known whether wounded service members are infected when they depart the theater allows the possibility of another source of infection: exposure while in the U.S. Air Force medical evacuation system. An initial evaluation of two aeromedical evacuation flights in January and

[43] Christopher Heath, et al., "A review of the Royal Perth Hospital Bali experience: an infection control perspective," *Australian Infection Control,* 2003:8(2) 43-54.
[44] U.S. Army Center for Health Promotion and Preventive Medicine, Interim Report, *Epidemiological consultation on the investigation of* Acinetobacter baumannii *infections in U.S. military treatment facilities*, 11 November 2004.
[45] Colonization is the growth of organisms on or in the body, while infection develops when these organisms begin to cause a disease that harms the body.

February 2005 raised concerns about adherence to infection-control practices but did not identify any obvious *A. baumannii* transmission.[46]

The practice of forward surgical treatment may contribute to the risk of antibiotic resistance. Warfighters who may already be colonized or infected with *A. baumannii* or other organisms are having orthopedic surgical appliances (pins and rods used to stabilize fractures) emplaced in theater or at Landstuhl Regional Medical Center. This aggressive surgical management may seem to provide better care for the immediate battlefield wounds, but when these service members later develop bloodstream infections, the surgical appliances act as foreign objects that sequester bacteria, allowing them to evade both the body's natural defenses and the antibiotics that are administered to treat the wound and bloodstream infections. These service members are often being treated for six weeks with very strong antibiotics, yet still must have the appliance surgically removed when the bloodstream infection fails to clear. They are then treated with antibiotics for a second six weeks to eliminate the infection. These treatments are not only expensive, but they also breed resistant bacteria at other sites, such as the respiratory tract and the bowels. In an attempt to prevent these infections, some injured casualties from Iraq are having Primaxin and other powerful, broad spectrum antibiotics administered prophylactically. While on the surface this may seem like a good practice, it is likely causing the development of resistance that will quickly make the antibiotics useless.

Although vascular surgeons may occasionally place plastic grafts on injured arteries in-theater, this is only done to keep the injured limb alive and is understood to be a temporary measure that needs to be surgically corrected once the wound is completely debrided and all infection is eliminated. Few military combat casualty care experts are advocates of placing internal orthopedic surgical appliances in-theater. Orthopedic surgery guidelines in World War II prevented this practice by prohibiting the internal placement of any metallic devices forward of an evacuation or general hospital.

A potential partial solution to this dilemma is to revisit the short-lived World War II notion of topical application of antibiotics to combat wounds. American studies at the time concluded that initial topical application of sulfonamide antibacterial agents to severe, contaminated wounds was of little value, and the correct doctrine of immediate surgical debridement was developed. German soldiers, on the other hand, were provided with packets that also contained mafenide hydrochloride, a different form of sulfonamide that was not inhibited by wound fluids and pus as are the sulfa derivatives tested by the United States.[47] Germany used mafenide hydrochloride powder in the field to prevent gas gangrene associated with combat wounds. The United States turned instead to the newly discovered penicillin, which was thought to be 60 times more effective against the organisms causing gas gangrene.

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[46] Paul Doan and James Stewart, *The Environmental Surveillance for Acinetobacter baumannii in the Air Evacuation System*, United States Air Force School of Aerospace Medicine, 12 May 2005.

[47] Janice Mendelson, "Topical Mafenide Hydrochloride Aqueous Spray in Initial Management of Massive Contaminated Wounds with Devitalized Tissue," *Prehospital and Disaster Medicine*, July-September 2001, 16 (3): 172-174.

Local administration of antibiotics in combat wounds offers other advantages over the current practice of intravenous administration. War wounds often have large amounts of dead and devitalized tissue, and systemically administered antibiotics do not penetrate areas where local blood vessels are damaged.[48] The doctrine of the past 50 years should be revisited, not to replace prompt surgical debridement with the administration of antibiotics, but to add early application of a topical antibiotic or antiseptic to severe, contaminated wounds, perhaps as early as when the injured warfighter is first seen by the combat medic in the field.

In summary, a number of factors may be causing or contributing to problems with *A. baumannii.* First, normal bacteria that colonize the human body and keep dangerous bacteria in check are being destroyed by Primaxin and other antibiotics that are overused in-theater or while casualties are evacuated. Second, *A. baumannii* is an opportunistic infectious agent that infects wounds where the body's usual healing mechanisms are severely compromised by large amounts of tissue damage, devitalized tissue, and poor blood flow. Third, there may be cross-contamination between U.S. troops and Iraqi casualties treated in the same medical facility. Extensive studies are underway to collect more data that may answer some of these questions. Pending the results of these studies, prompt action is required. Actions should be taken that will help to reduce the levels of infection in service personnel and diminish the transfer of bacteria to other clinical settings and third-party patients.

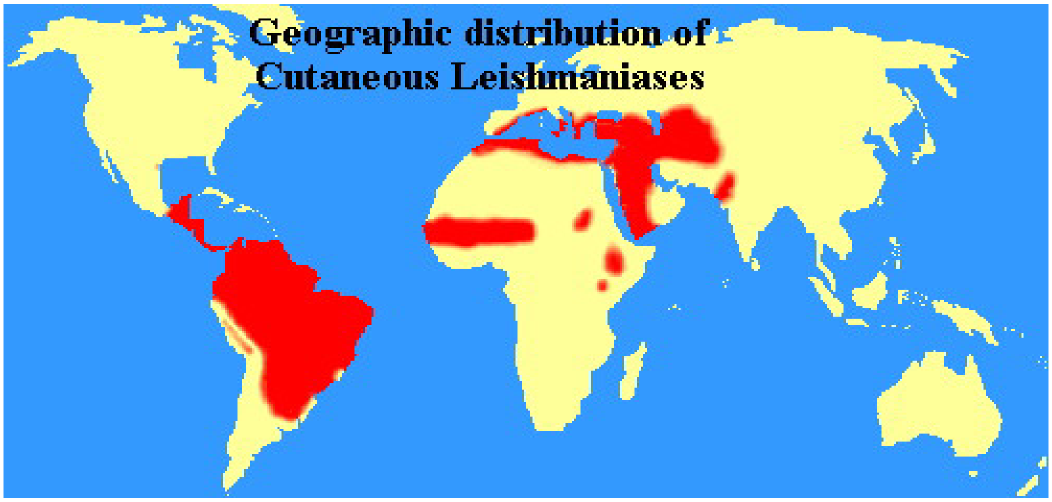
Case Study II—Leishmaniasis: Battle Scars of the 21st Century?

Until recently, the malaria parasite and the mosquito have been the pathogen-vector pair most detrimental to military forces in the past few centuries. They have been replaced by the protozoan parasite *Leishmania* and its insect vector, the sand fly of the genus *Phlebotomus* (see figure 11). This pair causes three clinical syndromes in humans: cutaneous Leishmaniasis, mucosal Leishmaniasis, and visceral Leishmaniasis. There are at least 13 species of the Leishmania parasite, divided into Old World and New World categories. Leishmaniasis is found widely in Central and South America, Africa, around the Mediterranean Sea, and in the Middle East and Central Asia.

Some of these species have an animal reservoir in nature (burrow-dwelling rodents, dogs), while others are transmitted only from human to human by the female sand fly. The primary syndrome seen in U.S. service members in the Middle East is the Old World cutaneous form, where a dry ulcer slowly begins to grow several weeks after a sand fly bite. The person may first notice only "an infected insect bite," but typically becomes concerned when a chronic, painless ulcer continues to grow over several months. The ulcers caused by the Old World parasite often resolve spontaneously over months to years, but can leave behind a disfiguring scar called an "oriental sore" or "Baghdad boil." Infections caused by the New World parasites are more aggressive and often require treatment to prevent the more serious visceral or mucocutaneous form from developing.

[48] Charles Heisterkamp, et al., "Topical Antibiotics in War Wounds: A Re-Evaluation," *Military Medicine,* January 1969, 13-18.

Figure 9



Source: COL Naomi Aronson, Uniformed Services University of the Health Sciences, 24 Jun 05.

The visceral form is called *kala-azar*, and is much more dangerous. The infected person may not get sick for months after the sand fly bite, but then typically develops fever, loss of appetite, weight loss, muscle wasting, enlargement of the liver and spleen, and anemia. Visceral leishmaniasis can be life threatening if not treated.

Management of these infections has been a challenge for the medical community due to difficulties in diagnosis and treatment. The cutaneous lesions are rarely properly diagnosed on the first visit to a health care professional.[49] Antibiotics are often prescribed and have little or no effect. An initial diagnosis of cutaneous leishmaniasis is often made upon finding the parasite from tissue scrapings or a skin biopsy of the edges of the ulcer, and from bone marrow or liver biopsies for visceral leishmaniasis. No clinically useful blood or skin screening test exists. Effective treatment often requires intralesional or intravenous sodium stibogluconate, an antimony compound in investigational new drug status available only from the CDC. This medication causes well-known toxic reactions that include weakness, fatigue, headaches, muscle aches, joint stiffness, nausea, vomiting, and elevation of liver and pancreatic enzymes. Treatment takes from three to four weeks, and patients require another two to three weeks of convalescence after treatment before resuming demanding physical activity.[50] Alternative medications, such as amphotericin B and pentamidine, are used primarily when the parasite is resistant to antimony, but must

[49] Alan Magill, Cutaneous Leishmaniasis in the Returning Traveler, *Infectious Disease Clinics of North America,* March 2005, 19: 241-266.
[50] Samuel Martin, et al., Leishmaniasis in the United States Military, *Military Medicine,* December 1998, 163 (12): 801-807.

also be administered intravenously and have significant toxicity. A new lipid complex form of amphotericin B has been approved by the Food and Drug Administration for visceral leishmaniasis, but does not appear to be effective for cutaneous leishmaniasis.[51]

Alternative treatment options have been examined for cutaneous leishmaniasis, based on the infecting parasite strain, the immune status of the patient, and the locations of the ulcers.[52] On September 10, 2004, the U.S. Army released management guidance for suspected cases of cutaneous leishmaniasis that summarize when intravenous treatment is appropriate and when no treatment is appropriate, for example, if lesions are small and already starting to improve, are not located in sensitive areas of the body, such as over joints, on the face, ears, nose, or feet, and are not bothersome to the patient or family.

Leishmaniasis was a minor problem for the U.S. military during Operation *Desert Shield/Desert Storm*, when only 32 cases were seen in service members.[53] Twenty of these cases were the cutaneous form, but military medical experts were surprised when there were 12 cases of a visceral-like leishmaniasis in an area that was not known to have visceral leishmaniasis.[54] This new presentation of the infection was called viscerotropic leishmaniasis. Treatment costs to the U.S. military are significant. Until recently, most of the evaluation and treatment of leishmaniasis took place at Walter Reed Army Medical Center, where about 420 cases were seen between 1967 and 1998, mostly in soldiers deployed to Panama. Providing proper care for these active duty and reserve service members was a long, costly, and complex process: direct costs for treatment were estimated to exceed $17,000 per patient and to result in an average of 92 lost duty days per patient.[55] Current treatment costs are about $11,000 per soldier and involve about 40 days lost from duty.[56]

There has been an explosion of cases of leishmaniasis since OEF/OIF began. There have been almost 1,000 cutaneous cases and five visceral cases in the first two years. The low number of cases in Operation *Desert Storm* may have lulled DOD into a false sense of security. Most infected service members did not understand the risk of the disease or their need for personal protective equipment (PPE). Many shared the misperception from Operation *Desert Storm* that DEET insect repellant and permethrin-treated uniforms were more toxic than useful.[57] PPE was often unavailable, as combat movements early in the war outstripped supply lines. There also has been more urban and peri-urban deployment of U.S. forces, compared to Operation *Desert Storm,* during which most forces were in open desert, where the sand fly vector is less common. Sand fly activity is greatest in Iraq in the fall, and in some areas of Iraq where large troop populations were conducting their

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[51] Glenn Wortmann, et al., "Failure of Amphotericin B Lipid Complex in the Treatment of Cutaneous Leishmaniasis," *Clinical Infectious Diseases*, April 1998, 26:1006-7.
[52] Magill, 241-266.
[53] Martin, et al., 801-807.
[54] Alan Magill, et al., "Viscerotropic Leishmaniasis in Persons Returning from Operation Desert Storm—1990-1991," *Morbidity Mortality Weekly Reports*, February 28, 1992, 41 (8): 131-134.
[55] Martin, et al., 801-807.
[56] COL Naomi Aronson, Uniformed Services University of the Health Sciences, 24 June 05.
[57] One of the rumored causes of Gulf War Illness was the use of DEET insect repellent and permethrin-treated uniforms. A Google search provides over 6,600 web pages on this subject.

missions, roughly two percent of sand flies were infected with the Leishmania parasite.[58] Early in the combat phase of the war, troops slept outside their armored vehicles with as little clothing as possible, leading to hundreds of sand fly bites in some cases, as illustrated by figure 11. As security became more of an issue, more service members were housed in secure, air-conditioned buildings, so sand fly exposure was greatly reduced.

Figure 10

Figure 10 – Sand Fly Bites

Source: COL Naomi Aronson, Uniformed Services University of the Health Sciences, 24 June 2005.

Sand flies and rodents breed in accumulations of garbage and debris and in the rubble around airstrips, so the poor sanitary conditions associated with urban warfare increase the risk of troop exposure. Sand flies are weak fliers and only travel about 100 meters from their dark, moist resting places. These characteristics result in focal areas of very high transmission, especially near Talifar and Tallil Air Base where PPE is still not being used properly. Two Stryker Brigades accounted for over 250 cases in the first six months of 2005.

A concern is that many of these cases are not being reported via the military disease surveillance systems and may be lost to follow-up. Many of the infected service members do not need the intensive intravenous treatment at Walter Reed Army Medical Center or Brooke Army Medical Center and are managed locally with heat treatment or cryotherapy. Often their diagnoses are made based on clinical findings rather than laboratory identification of the parasite and are not captured by disease surveillance systems. Unless a comprehensive disease surveillance system is in place that tracks all of these service members, military medical personnel will only learn about their cases when they get sick enough to seek care.

The puzzling aspect of leishmaniasis in OIF is why so many troops are getting infected when much is known about its prevention. As with malaria prevention, insect bites can be

[58] Dennis White, Survey of Repellent Use by Service Members Arriving in Kuwait for Operation Iraqi Freedom 2, *Military Medicine*, June 2005, 170(6): 496-500.

greatly reduced if specific steps are taken to reduce the warfighter's exposure. It is possible to identify resting and breeding sites of sand flies and avoid these areas or take steps to eliminate them as much as possible. Geographic information system technology and remote sensing using commercially available satellite environmental data have been used for many years to identify insect vectors of diseases, allowing intervention efforts to be targeted at the highest risk areas.[59] Numerous methods have been described for applying insecticides and baits that can suppress sand fly attacks for two to four months with each application.[60] Personal protection is essential to prevent sand fly and mosquito bites, and has been incorporated into military doctrine. Despite its effectiveness, service members' adherence to prescribed measures is often inadequate, and the logistical support for providing personal protective supplies is questionable.[61] DOD is reemphasizing the risks of leishmaniasis to heighten awareness on the part of service member, but a recent report indicated that only one-third of an Army Reserve unit that arrived in Kuwait in March 2004 received the appropriate education and protective supplies.[62] This suggests that the reason for infection in these troops is not mysterious at all, but reflects failure to consider all the appropriate logistics and personal protective measures.

The card shown in figure 11 is provided to all soldiers deploying in OEF and OIF.[63] The reverse side of the card reminds them to seek medical assistance if they develop a fever or sore that will not heal, to tell the doctor that they have been deployed to an area with a high risk of leishmaniasis exposure, and to show the card. The card contains names and phone numbers of Army experts who can provide diagnostic kits and clinical management assistance.

[59] Donald Thompson, et al., "Bancroftian Filariasis Distribution and Diurnal Temperature Differences in the Southern Nile Delta," *Emerging Infectious Diseases*, July-September 1996, 2 (3):234-235.
[60] Martin, 801-807.
[61] White, 496-500.
[62] Ibid.
[63] Permission to use card given by COL Naomi Aronson, Uniformed Services University of the Health Sciences, 24 June 2005.

Figure 11

Leishmaniasis

Leishmaniasis is caused by a parasite (leishmania) that gets into people when infected sand flies bite them. You could be at an increased risk of getting this disease if you have been deployed to certain parts of Iraq. There are two kinds of disease: Cutaneous (skin) & Visceral (internal organs). The skin form is seen as a sore that will not heal, even after several weeks to months and antibiotic treatment. Visceral is seen as fevers that will not go away (often with high spikes twice a day) even after several weeks and antibiotic treatment. If you have either of these symptoms, you should seek medical attention and say that you have been deployed in an area with a high risk of leishmania exposure. There is no vaccine or preventive drug. There is a special drug treatment done at Walter Reed in Washington D.C. The best way to protect yourself is to use permethrin-treated uniforms and bed nets, as well as insect repellent.

Skin sores from Leishmania. These can last for months untreated.

Sand Fly Feeding

Joint Recommendation: Improve Infection-Control Practices in the Field and in Fixed Hospitals

- *Military planners should plan for fixed medical care facilities that allow better infection control.* Planners should rapidly identify fixed structures for patient care areas in-theater to provide suitable infection-control environments for operating rooms and intensive care units. These structures should be converted for hospital use as soon as major combat operations and the security situation permits. Alternatively, fixed structures with concrete floors should be built as part of deployed field hospitals for these important patient care areas. Difficulties with maintaining infection control and preventing transmission early in OIF, in both field hospitals and the U.S. Navy hospital ship USNS Comfort, included shortages of hand hygiene products, sinks, gowns, and repeated shortages of antibiotics, and an inability to properly cohort casualties. The Air Force emphasized improving hospital structures by pouring concrete pads for field hospitals and constructing doors between wards to reduce environmental contamination and spread, but other field hospitals in Iraq still had canvas tents and dirt floors two years after the war began.

- *Evaluate and reinforce infection-control practices throughout the continuum of combat casualty care.* This is especially important in military, civilian, host nation, and Veterans Health Administration facilities where combat casualties and civilians are treated in the same institution. There were many more cases of nosocomial infections at Walter Reed Army Medical Center than at the smaller Landstuhl Regional Medical Center in Germany, despite the much higher proportion of infected

patients being admitted at Landstuhl. While this is probably due in part to the younger, healthier patient population at Landstuhl and relatively short hospitalizations, infection-control practices must be reemphasized, particularly in these high-risk hospital settings. Patients with immunocompromised family members and with very young children may need special attention.

- *Reevaluate the size and capabilities of the medical footprint within the combat theater.* Medical experts must determine what force structure changes are necessary to provide adequate debridement of severe soft tissue wounds, and what are the logistics and resource costs of improved early diagnostics and treatment for potentially communicable diseases before aeromedical evacuation. Medical, logistics, and personnel planners must determine the best balance between in-theater surgical care for the highest risk injuries and the logistics cost of providing these capabilities.

Joint Recommendation: Cooperative Iraqi-American Disease Investigation

- *Undertake a cooperative scientific investigation with Iraqi medical authorities of infections in injured Iraqi service members so that disease prevalence and transmission risks can be better characterized.* Many Iraqi casualties are being treated in U.S. Combat Support Hospitals for a period of many weeks, and have positive *A. baumannii* respiratory and wound cultures, suggesting that the organism is much more common in Iraq than thought. A collaborative U.S.-Iraqi study could provide considerable lessons learned that might improve combat casualty care for both nations.

United States European Command (EUCOM)

The EUCOM AOR includes many geographic areas that have limited fixed medical facilities with advanced diagnostic capabilities. There is significant political instability in some African countries, rising concern over failed states, and a high incidence of intrastate conflict with subsequent internal refugee crises. U.S. military forces deployed into these countries have often encountered major infectious disease threats that have reduced combat effectiveness. The following case study describes an operational dilemma that could be faced by EUCOM today.

Case Study III—Hemorrhagic Fever Viruses: Hot Zones

In early 2005, person-to-person transmission of Marburg virus infection was reported in Angola, where the fatality rate approached 80 percent. As of August 24, 2005, the Ministry of Health in Angola had reported a total of 374 cases and 329 deaths countrywide. New infections continued to develop despite intensive intervention by WHO and other international aid organizations. In many cases, due to a lack of adequate knowledge of virus transmission and control measures, hospital staff and family members of patients infected with the virus became victims of the virus. Another hemorrhagic fever virus, the Ebola virus, caused 12 infections and nine deaths as of June 16, 2005 in the Republic of Congo.

DOD policymakers have paid little attention to Ebola and Marburg hemorrhagic fever virus because the chance is remote that warfighters would deploy to Angola and the Republic of Congo. The fear of these illnesses is strong, however, because of popular books, such as *The Hot Zone* by Richard Preston, and the Dustin Hoffman movie "Outbreak."[64] A more significant danger is another pathogen called Crimean-Congo hemorrhagic fever virus. This virus is present in many areas, including some locations where the U.S. military has been involved. Cases have been reported in many countries in Africa, as well as Turkey, Iraq, Iran, Pakistan, United Arab Emirates, Kuwait, Oman, Kosovo, Albania, Bulgaria, Kazakhstan, Uzbekistan, Tajikistan, Russia, and China.[65]

Crimean-Congo hemorrhagic fever (CCHF) develops between three and nine days after a person is bitten by an infectious tick or comes into direct contact with blood or infected tissues from a person or from livestock. Symptoms include sudden onset of fever, chills, muscle aches, nausea, vomiting, and headache. These symptoms are similar to those seen in many other infections, including influenza and malaria. Advanced symptoms include bleeding into the skin, causing skin rashes, and bleeding from the upper bowel, blood in

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[64] Richard Preston, *The Hot Zone: A Terrifying True Story* (New York: Random House, 1994).

[65] Multiple sources including ProMED (International Society for Infectious Diseases); *Control of Communicable Diseases Manual, 18th Edition,* (American Public Health Association); *Health Information for International Travel* (Centers for Disease Control and Prevention); and *Emerging Infectious Diseases* (Centers for Disease Control and Prevention).

the urine, nosebleeds, and bleeding from the gums. An additional risk for U.S. military forces is from nosocomial (hospital-acquired) transmission. CCHF is easily transmitted by blood and body fluids, so the risk to healthcare workers and others who come into contact with ill persons is significant. The antiviral medication Ribavirin is effective, but is not FDA approved for CCHF treatment. Untreated, CCHF has a case fatality rate between 5 and 50 percent, with an average case fatality rate of 30 percent.

Transmission to another service member could take place during the incubation stage, early in the clinical stage during the few days before an infected service member seeks medical attention, either in the field or in transit, or during the two-week hospitalization required for patients while the infection runs its course. Effective infection-control measures in the hospital setting (blood and body fluid precautions) largely prevent in-hospital transmission of CCHF, but practices recommended for care of civilian patients in civilian hospitals may not be possible in a field setting, in the aeromedical evacuation system, or in a fixed military MTF where there are multiple casualties from combat injuries or infectious diseases.

Seoul Hemorrhagic Fever, which causes hemorrhagic fever with renal syndrome, develops from one to five weeks after exposure to aerosols from fresh urine of infected rodents (specifically, the Norway rat, which is found worldwide), often when dust contaminated by rodent excreta or urine is stirred up. This exposure usually occurs in rural settings, though it has been found in urban settings in Seoul, Korea, in persons who had not traveled outside the city. Symptoms include fever, shock, and kidney failure. While Seoul Hemorrhagic Fever does not pose the risk of transmission from person to person, it cannot be treated with Ribavirin, as can CCHF.

In a deployed setting, all service members who are suspected of having a hemorrhagic fever must be strictly isolated to protect healthcare workers and other patients from infection. Once a laboratory diagnosis is made, infection-control measures may be tailored for the particular infection, but until this additional diagnostic information is obtained and confirmed, such patients must be managed as if they are carrying the most contagious virus.

Standard infection-control recommendations include a private room, face shields or surgical masks, eye protection, gowns and gloves, plastic aprons, leg and shoe coverings for protection from large amounts of blood and vomit, restriction of non-essential contact with others, and careful removal and disposal of protective gear upon leaving the patient’s room. Many of these infection-control procedures are difficult in a field setting. In the event that a diagnosis has not yet been made, care for these types of infections is complicated by airborne precautions for respiratory diseases. Influenza, SARS, plague, and many other infectious respiratory diseases, as well as hemorrhagic fever viruses, will be under consideration as possible causes of symptoms until a definitive clinical and laboratory diagnosis is made. Such respiratory precautions are difficult, if not impossible, in field conditions. These precautions include negative air flow, sealed isolation rooms, high-efficiency air filters, and an anteroom for personnel to don and doff personal protective equipment and to prevent respiratory aerosols from escaping into the corridor.

Respiratory precautions will by necessity be minimal until service members reach large medical centers, so a lowered threshold for suspicion of such infections and careful tracking of other service members who may have been exposed is crucial to prevent disease outbreaks. The ability to move highly infectious patients by the military aero-evacuation system will face formidable obstacles jeopardizing patients, staff, and the military patient movement equipment. International patient movement of highly infectious patients across non-U.S. borders may incite fears leading to denial of permission to enter the airspace of other countries.

Even in fixed medical facilities, costs of infection control are significant. Direct costs of disposable supplies for multiple patient visits each day may add thousands of dollars to the cost of each hospitalization. Efforts to decrease unnecessary instances of patient contact, on the other hand, lead to lower quality of medical care.[66] A recent study indicated that isolated patients had half as many hourly contacts with healthcare personnel, had fewer medications prescribed, and were more likely to experience preventable adverse events, such as falls and inadequate management of disorders of fluid and electrolytes.[67]

Joint Recommendation: Develop a rapid field diagnostic capability for diseases of military operational importance

- *Fast-track the development and implementation of a rapid field diagnostic capability for diseases of military operational importance.* Diseases associated with fevers are major causes of illness and death in military and civilian travelers to Africa. There are dozens of possible causes for a fever in a service member in and after returning from Africa, including malaria, Crimean Congo hemorrhagic fever, Ebola and Marburg hemorrhagic fevers, Lassa fever, Rift Valley fever, yellow fever, influenza, plague, Q fever, leptospirosis, African trypanosomiasis (African Sleeping Sickness), African tick bite fever, and tuberculosis. Some of these possibilities are very unlikely in certain geographic areas, and several (yellow fever, measles, mumps, rubella, diphtheria, polio) are prevented by up-to-date immunizations. Most, however, can only be diagnosed with advanced clinical laboratory testing equipment after the service member is evacuated to Germany or the United States. The development of a rapid, gene-based diagnostic testing capability that can be deployed into the field is essential to allow in-theater diagnostics and treatment. Such diagnostics should detect organisms in wounds and on environmental surfaces, should provide crucial antibiotic susceptibility data, and should provide genetic fingerprinting analysis that will permit identification and disruption of person-to-person transmission of pathogens currently affecting combat operations in the EUCOM command region. Knowledge of species-specific information will permit military physicians to properly stratify infected service members based on risk from the particular parasite.

[66] Henry Stelfox, David Bates, and Donald Redelmeier, "Safety of Patients Isolated for Infection Control," *Journal of the American Medical Association*, 8 October 2003, 290(14):1899-1905

[67] Persons with serious medical conditions such as congestive heart failure or diabetes require close attention to protect from over- and under-hydration, and to monitor and correct the sodium, potassium, and other electrolytes in their blood.

United States Northern Command (NORTHCOM)

The NORTHCOM AOR contains the greatest challenges for the Department of Defense. North America has some of the most advanced medical diagnostic, treatment, and research capabilities, has seemingly endless resources, and has outstanding ground and air transportation networks and communication and computer infrastructure. While each of these factors taken in isolation would seem to ease the control of infectious diseases and provide a reprieve in force protection efforts, the complex interaction between the different components within DOD, the as-yet-undefined homeland security roles and responsibilities at the Federal, state, and local levels, and the lack of a strategic national game plan precludes any meaningful planning for controlling infectious disease transmission in the Continental United States. At the point where warfighters come into contact with civilians in the United States, whether healthcare workers or other beneficiaries in DOD MTFs, their own family members, or the general public, the control of any infectious disease transmissible from person to person is beyond the influence of the military, and is instead up to the civilian public health system, which is not prepared or resourced for unfamiliar diseases.

These issues will assume critical importance in the event of an outbreak of highly contagious influenza. The current outbreaks of avian influenza in Asia and continued human cases suggest that concerns of a worldwide pandemic are valid. The following case study looks at the impact of the 1918-1919 outbreak of influenza and the possibility that troop movements directly contributed to its worldwide spread. It describes some of the military equities in such an epidemic and identifies areas where NORTHCOM must engage in order to be prepared to respond effectively in the case of such an event.

Case Study IV—Pandemic Influenza

The Spanish Flu of 1918-1919 was the single most deadly outbreak of disease in the 20th century, perhaps in the entire world history of disease. The first wave of influenza began in the spring of 1918, causing mild occurrences of flu in the United States and across the globe. Some historians believe that the first instance of the disease erupted as early as late January and early February 1918 in Haskell County, Kansas, where it is believed to have spread to Camp Funston, the second largest army camp in the country, housing an average of 56,000 troops. In the spring of 1918, thousands of soldiers became sick with influenza-like symptoms, resulting in 237 cases of pneumonia and 38 deaths.[68] The first unusual outbreaks of influenza in Europe occurred in Brest in early April 1918 with the arrival of American troops, followed by mild occurrences of the virus in France, Germany, England, and Spain.

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[68] John M. Barry, *The Great Influenza: The Epic Story of the Deadliest Plague in History* (Penguin Books: 2004), 96.

Beginning in August 1918, a highly virulent and lethal strain of the virus began to sweep the globe, appearing on the Indian subcontinent and in China, Japan, and Southeast Asia, killing thousands. Cases of influenza in the United States from this second wave first appeared in Boston, Massachusetts, and in Camp Devens, Massachusetts, in late August and early September, then rapidly appeared in military bases and cities up and down the East Coast,[69] including Camp Dix, New Jersey, and Camp Meade, Maryland. "In a single day, 1,553 Camp Devens soldiers reported ill with influenza. On September 22, 19.6 percent of the entire camp was on sick report, and almost 75 percent of those on sick report had been hospitalized."[70]

At Camp Sherman, Ohio, every third man reported ill. At Camp Meade, 27 percent of the 42,300 troops were hospitalized. The hospital had a capacity of about 1,000 beds, but in just one day had to admit 875 flu patients.[71] The influenza virus continued to spread to military bases and cities throughout the country, causing massive illness and thousands of deaths. In a single day at Camp Custer, outside Battle Creek, Michigan, 2,800 troops reported that they were sick.[72] Relief and medical efforts to stop the spread of the disease in many of the cities was severely hampered due to a lack of supplies and volunteers healthy enough to care for those infected with the influenza virus. Hospitals were quickly overfilled with the sick and dying, and ill people lined up for countless hours in hopes of receiving medical care. There were not enough medical supplies, doctors, or nurses to care for the sick. Businesses were closed throughout the country, public gatherings were cancelled, and bodies were left in the streets once hospitals and morgues were filled up, often being buried in mass graves because of a shortage of caskets.

The deadly influenza pandemic reached Camp Lewis, Washington, in mid-September following the arrival of a ship carrying soldiers from Philadelphia, then traveled along the West Coast, eventually reaching Alaska, where it decimated small communities, in some cases, killing all the inhabitants of remote Eskimo villages.

The second wave of the pandemic influenza outbreak peaked and began declining worldwide by the end of December 1918. Some countries, however, continued to experience a third wave of disease in the early months of January and February 1919. Because many countries that experienced the 1918-1919 influenza pandemic did not have reporting measures in place for the occurrence of disease, the exact number of deaths worldwide is not known. What is known is that the Spanish Flu killed more people worldwide than recorded combat deaths in World War I. Conservative estimates place the number of deaths at upwards of 50 million people worldwide, with 500,000 deaths in the United States and as many as 6 million deaths in India alone.[73] Since 1918, two more

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[69] Ann H. Reid et al., "1918 Influenza Pandemic Caused by Highly Conservative Viruses with Two Receptor-Binding Variants," *Emerging Infectious Diseases*, October 2003, vol. 9, no. 10.
[70] John M. Barry, *The Great Influenza: The Epic Story of the Deadliest Plague in History* (Penguin Books: 2004), 87.
[71] Carol Byerly, *Fever of War: The Influenza Epidemic in the U.S. Army during World War I* (New York: New York University Press,2005), 76.
[72] Barry, 217.
[73] David Parsons, "The Spanish Lady and the Newfoundland Regiment." Available online at: <http://www.ku.edu/carrie/specoll/medical/parsons.htm>.

significant influenza pandemics have occurred, in 1957-1958 and 1968-1969, although neither of them had as high a mortality rate as the 1918 influenza outbreak.

The 1957-1958 influenza epidemic originated in February 1957, in the Kweichow province of China and spread from China into the rest of Asia, the Middle East, and Europe, reaching North America in June 1957.[74] In 1968, a new flu strain, H3N2, originated in the Guangdong Provence in southern China and quickly spread around the world.[75] Pandemic influenza has not occurred since 1968, and it is widely believed that another pandemic influenza is overdue.

One recent concern is that the latest outbreak of avian influenza H5N1 virus in Asia will lead to the next influenza pandemic in the very near future. Identified in Italy more than 100 years ago, avian influenza is an infectious disease of birds caused by type A strains of the influenza virus.[76] In 1996, a strain of avian influenza was first detected in geese in China's Guangdong province, and by 1997, a massive epidemic of avian influenza virus in poultry had broken out in Hong Kong, leading to the mass culling of an estimated 1.5 million chickens.

Avian influenza viruses can be transmitted to humans in two ways: directly from infected birds or avian virus-contaminated environments (poultry farms, poultry slaughter areas, poultry markets), or through an intermediate host, often pigs.[77] The H5N1 virus is of particular concern because it mutates rapidly, can cause severe disease in humans, and has demonstrated resistance to known influenza antiviral medications. Since 1997, outbreaks of pathogenic avian influenza caused by the H5N1 virus have continued to cause fatal disease in humans throughout Asia. Over 115 human cases of avian influenza A (H5N1) have occurred throughout Cambodia, Indonesia, Thailand, and Vietnam. It is also believed that limited human-to-human transmissions have occurred, raising the fear in the international health community that the H5N1 virus could lead to the next influenza pandemic as human-to-human transmission increases.

[74] The Office of the Public Health Historian, The Lister Hill National Center for Biomedical Communications, "Influenza: A Short History of the Disease," 7 December 2004. Available online at: <http://lhncbc.nlm.nih.gov/apdb/phsHistory/health_news_text.html>.
[75] Ibid.
[76] United Nations Food and Agricultural Organization, "Avian Influenza— Background." Available online at: <http://www.fao.org/ag/againfo/subjects/en/health/diseases-cards/avian_bg.html>.
[77] Centers for Disease Control and Prevention, "Transmission of Influenza A Viruses Between Animals and People." Available online at: <http://www.cdc.gov/flu/avian/gen-info/transmission.htm>.

Figure 12

Figure 12 - Source: Photo by Larry Rana, USDA, Image Number: 95cs6917, CD2958-011.

Although estimates have varied, health experts from the CDC and from WHO have predicted that a new influenza pandemic could kill from two to fifty million people, depending on the pathogenicity of the virus, how fast it can spread, and if large enough supplies of an effective antiviral drug can be produced in time to stop a widespread infection.[78]

The threat of a rapidly spreading influenza within the United States will likely lead to irrational behavior and even panic as people try to protect themselves and their families from such a threat. Government authorities at all levels will be inundated as they try to allocate scarce medical resources. Freedom of movement will likely be reduced in an effort to limit disease spread. As movement of people is reduced, so will movement of goods and services. This will degrade the ability of military installations to resupply and to move service members and combat equipment from base to base or from the United States to an overseas location. As global power projection is key to U.S. military strength, these movement limitations must be considered and overcome before a pandemic hits.

[78] Martin Enserink, "WHO Adds More '1918' to Pandemic Predictions," *Science*, 17 December 2004, vol. 306, 2025.

DOD must proactively engage with Federal, state, and local authorities, and with private sector entities involved in freedom of movement. The military should be an active participant in any homeland security forum where prevention or response of a communicable biological weapon is an issue. There is an erroneous perception that the military would be involved in enforced restriction of movement. In actuality, the military is more likely to be used in maintaining movement of critical goods and services.

NORTHCOM should begin to close the preparedness and response gap by improving disease and personnel surveillance and response networks. Monitoring disease prevalence and tracking service members within the United States has largely been an afterthought, and the development of rapid decision-making and disease-control strategies has been nonexistent. DOD has recently developed policies for enforcing quarantine on military installations in response to a public health emergency, has begun to put in place a global emerging infectious disease surveillance system, and has been proof-testing a process that collects disease information from military installations in the United States and shares results with several civilian public health agencies. However, efforts are largely scattered between the services, and the resources applied to these efforts have been minimal. A timely, responsive capability that is likely to anticipate and prevent outbreaks is greatly needed to balance the considerable reductions of in-theater medical diagnostics and treatment capacity in recent years.

Perhaps the most crucial task for NORTHCOM is to engage with civilian medical and public health officials, and Federal, state, and local emergency planners to identify how and where a communicable disease will spread in the United States and what actions should be taken by whom to manage an outbreak. This is especially important with the growing threat of pandemic influenza. People will adapt to a crisis or a perceived crisis, with many unanticipated, undesirable consequences. For example, they may choose to stay home when it would be better for them to get antibiotics at a certain location, or they may leave home and travel to an area that puts them at increased risk for an infectious disease.

Joint Recommendation: Improve Civil-Military Cooperation on Epidemic Prevention and Response

- *Create a cooperative response system to respond to a communicable disease outbreak, such as pandemic influenza.* Build a core group of military, Federal, state, and local disease control officials to develop requirements for rapid disease investigation, contact tracing, movement and activity restrictions, and medical surge capacity. A strategy for national solutions should include identification of capabilities to meet each of these requirements, all possible military, Federal, state, local, private sector, and civil society organizations that can fill the gap between states and societies, to meet manpower and resource requirements, and proofs of concept to evaluate potential solutions in urban, rural, and regional settings. The primary role of DOD personnel should be to facilitate in the civilian sector the deliberative planning process that has been so successful within the military.

- *Create a Joint Operational Bioresponse Center that directly links civilian biodefense expertise with Combatant Commanders.* The Department of Homeland Security is developing a National Biodefense Analysis and Countermeasures Center at Fort Detrick, Maryland, in cooperation with the National Institutes of Health. The Center is staffed by personnel on detail from NORTHCOM and U.S. Pacific Command, assisted by medical intelligence analysts assigned to the Armed Forces Medical Intelligence Center, and the U.S. Army Medical Research Institute for Infectious Diseases at Fort Detrick. An operational DOD official attached to the Center will provide an essential link during a national epidemic control effort.

Joint Recommendation: Develop Improved Service Member and Disease Surveillance Process

Improved Management of Warfighters Evacuated from the Combat Theater

- *Carefully monitor and separately manage casualties from combat operations such as Iraq and Afghanistan because of the potential risk of transmitting infection.* When they return to the United States, injured soldiers should be kept separate from non-active-duty beneficiaries until risks for disease transmission have been identified and controlled. Concerning infection with *A. baumannii*, for example, the service members of concern should include severely injured warfighters, service members who have been in the operating room or intensive care unit in Combat Support Hospitals where *A. baumannii* transmission has occurred, and other service members who have been in contact with these first two groups. Service members injured or possibly contaminated with an infectious disease should be carefully monitored and managed when they are medically evacuated from the field, when they are stabilized and treated at Landstuhl Regional Medical Center in Germany or another location, and when they are hospitalized in the United States. They should be managed apart from elderly persons and those with other disease conditions that make them more susceptible to infection. The model should be the National Naval Medical Center, where a trauma service was established on one ward of the hospital, with all the other services (Orthopedics, Vascular Surgery, Neurosurgery, Internal Medicine) acting as consultants to this focused trauma service. This organizational modification effectively groups injured Marines in one geographic location, greatly reducing the opportunity for nosocomial infections to develop in other beneficiaries. These measures are serious and will require a significant commitment from DOD to provide aircraft for transportation and sufficient staffing for separate wards in hospitals. While one option is to close the intensive care units at, for example, Walter Reed to military dependents and retirees until the transmission is understood, better staff education and strict compliance with infection-control procedures may reduce the risk of transmission sufficiently until other measures are developed and put in place to prevent and manage these infections. In the case of *A. baumannii*, since these soldiers may develop drug resistant bacteria during their course of treatment, the possibility exists for them to transmit these other bacteria when they are moved to other hospitals. To protect patients in VA and other hospitals from drug resistant bacteria, the infected warfighters should not be moved beyond Walter Reed and the National

Naval Medical Center until it can be verified that they are not infected. This may occasionally compete with the desire to return the recovering warfighters to their home to be with their families as soon as possible, so decisions must be made based on the pertinent facts for each case and the capability for suitable risk mitigation.

Enhanced Syndromic Surveillance of Healthcare Workers

- *Monitor healthcare workers as a high-risk population that may provide advance warning of an infectious disease outbreak like influenza.* Such monitoring should become routine and might include thermal scanning at the beginning and end of each shift. Constant occupational exposure to potentially infectious persons in ambulatory clinical settings suggests that they will be the first exposed to an unknown infectious disease, including pandemic influenza, and so might show nonspecific signs, such as a mild fever in the first four to eight hours after exposure. Because they might also develop respiratory symptoms soon after exposure, they should not simply be allowed to stay home if they show early signs of an illness. This was the case in eight healthcare workers in Hong Kong when SARS first began to spread. These healthcare workers called in sick the day after they were exposed to a SARS patient at work. When an astute supervisor told them to come in to the hospital to be evaluated, they were all found to be infectious and were immediately isolated. Such careful daily monitoring of healthcare workers could provide 1 to 2 days additional early warning of a new or spreading communicable disease, and would allow these high-risk persons to be identified, isolated, and tested before they could transmit a potentially lethal communicable illness to family members, co-workers, and friends.

United States Pacific Command (PACOM)

The PACOM AOR contains the largest geographic region of the U.S. Combatant Commands and depends on rapid air travel for force projection. The Asian Pacific region contains multiple, strategic security partners of the United States, and the non-traditional security threat of infectious diseases, such as SARS and avian influenza, threaten many of the features of globalization—free trade, free travel, and free information flow. As international and regional preparedness efforts continue, PACOM must take steps to assure that strategic air transport remains unthreatened as a tool of global power projection.

PACOM shares many of the equities described for NORTHCOM concerning tracking of service members. Moving troops into and around the theater to meet security needs is paramount, and PACOM will depend on NORTHCOM to assure that troops moving from the continental United States during an influenza epidemic or pandemic, for example, are not incubating a communicable disease that could spread to PACOM forces and compromise combat effectiveness, and vice versa.[79]

Both commands will need to work with civilian health agencies to identify the most appropriate contagious disease control practices. As in controlling an influenza pandemic, enforced quarantine is unlikely to be considered today due to concerns about civil liberties. Voluntary movement and activity restrictions are likely to provide the added time required for extensive case tracking and identification, but civilian and military public health officials must be prepared for the rapid contact tracing and decisionmaking that will be required.

Case Study V—Severe Acute Respiratory Syndrome

The emergence of SARS in 2002 surprised international public health experts and showed how vulnerable the world had become to contagious disease. The SARS epidemic of 2002-2003 demonstrated the ease with which a local outbreak can quickly become a worldwide epidemic. The virus ultimately spread to more than two dozen countries and administrative regions within six months, generating a massive global public health response. Hospitals in Singapore, Hong Kong, Vietnam, and Canada struggled to contain the virus when people unknowingly infected with SARS gave it to dozens of other people with whom they came in contact, including family members, hospital workers, and other travelers. As of the end of 2003, there had been 8,096 cases

[79] In the field of epidemiology, an *outbreak* is a large number of cases of a disease occurring in a short period of time. An *epidemic* is a more scientific description after an investigation is begun that confirms numbers based on a specific case definition and the usual numbers of such cases expected in the particular area in a defined period of time. A *pandemic* is a global epidemic.

worldwide and 774 deaths.[80] The epidemic had dramatic effects on the global economy, with one model estimated that the short-term global cost of lost economic activity was approximately $80 billion.[81]

SARS is a viral respiratory illness caused by a coronavirus, called SARS-associated coronavirus (SARS-CoV). The virus that causes SARS is thought to have been transmitted from civet cats, small wild mammals that were taken from their native environment to local markets, where they were sold for human consumption. Human exposure is likely to have occurred in the crowded and unsanitary market conditions.[82]

The first recorded case apparently occurred in mid-November 2002, in the city of Foshan, Guangdong Province, China. However, the Chinese Ministry of Health did not report to WHO that there had been 300 cases and 5 deaths in an outbreak of "acute respiratory syndrome" until February 2003. Confusing the response to these initial cases was the presence of cases of H5N1 avian influenza, with three deaths among members of a Hong Kong family who had traveled to Fujian Province.

The SARS virus was carried out of southern China on February 21, 2003, when a 64-year-old medical doctor who had treated patients in Guangzhou and was himself suffering from respiratory symptoms checked into a room of the Metropole Hotel in Hong Kong. He subsequently transmitted the SARS virus to at least 16 other guests, who carried the disease to Toronto, Singapore, and Hanoi, as well as hospitals in Hong Kong.

Despite its low transmission rate and the relatively low number of deaths compared to other infectious diseases, SARS had a very powerful and negative psychological impact worldwide. The newness of the disease, the speed of its global spread, the identification of several superspreaders who transmitted the infection to dozens of others, and public uncertainty about the ability to control its spread probably contributed to public alarm. This alarm led to behavior that worsened the economic impact by reducing travel and tourism to affected countries. Other behaviors reduced the ability of governments to control transmission of the disease. For example, in late March 2003, when Hong Kong officials quarantined the Amoy Gardens apartment complex, where over 300 residents became ill, they found that two thirds of the approximately 1,000 residents had already fled.

Extensive study of compliance with quarantine control measures in Toronto revealed a number of obstacles to compliance that will likely reoccur in the event of a contagious disease epidemic in the United States. Barriers to compliance with voluntary quarantine measures/movement restrictions included: fear of loss of income; inconsistencies in the application of quarantine measures between jurisdictions; spotty monitoring of

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[80] World Health Organization, "Summary of probable SARS cases with onset of illness from 1 November 2002 to 31 July 2003." Available online at: <http://www.who.int/csr/sars/country/table2004_04_21/en/index.html>.

[81] Jong-Wha Lee and Warwick J. McKibbin, "Estimating the Global Economic Costs of SARS," in *Learning from SARS: Preparing for the Next Disease Outbreak, workshop summary*, (Washington, DC: National Academies Press, 2004), 11.

[82] Ibid., 4.

compliance; difficulties with logistical support for infection-control supplies, medications, and food; psychological stress as a result of social distancing and stigmatization; and unclear government communication to the public.[83]

A number of lessons from the SARS outbreak can be applied to future outbreaks of disease. A wide variety of traditional health methods, coupled with modern technology, allowed for countries to better contain the outbreak and eventually stop the spread of the virus. PACOM should carefully consider these methods to better prepare for a future infectious disease outbreak, including: isolation of patients, quarantining contacts, canceling mass gatherings and closing schools, recommending that the public augment personal hygiene and wear masks, issuing travel advisories and screening travelers at borders, and using infrared and thermal scanning of travelers at borders to detect an elevation in body temperature that could be indicative of a fever.[84]

Furthermore, the interaction of public health needs and national security needs were studied in the context of the SARS epidemic by a recent Defense Science Board Task Force on SARS Quarantine.[85] The findings and recommendations from this task force apply in general to public health emergencies and disease outbreaks and should be considered not only by PACOM but the entire DOD:

- Many quarantine and isolation procedures exist, and they need not be perfect to reduce disease transmission. The military must not be seen to be responsible for pandemic spread of a disease. Costs of extensive quarantine are very high and provisions would be needed to care for those immobilized by quarantine restrictions.
- A comprehensive national and international civilian-military exercise program should be developed that addresses trans-jurisdictional quarantine issues, establishes mutually agreed upon protocols, and tests these plans through tabletop and actual exercises. Systems and tools should be developed to collect, organize, and provide for real-time tracking of an outbreak.
- Military force protection strengthens civilian defense from and response to an outbreak. DOD capability to perform its mission could be limited if there is no plan for immediate protection of the force. DOD caution in adopting a supporting role in response to an outbreak and related consequence management may result in delayed action when immediate action is demanded.
- Lack of suitable isolation facilities in the event of a large outbreak will be a limiting factor. DOD should consider new technologies and alternative approaches to isolation.

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[83] Clete DiGiovanni, et al., “Factors Influencing Compliance with Quarantine in Toronto during the 2003 SARS Outbreak,” *Biosecurity and Bioterrorism: Biodefense Strategy, Practice, and Science,* 2004, 2 (4): 265-272.

[84] David M. Bell, World Health Organization Working Group on Prevention of International and Community Transmission of SARS, “Public Health Interventions and SARS Spread, 2003,” *Emerging Infectious Disease,* 2004, 10(11).

[85] Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics, Interim Report of the Defense Science Board Task Force on SARS Quarantine, December 2004. Available online at: <http://www.acq.osd.mil/dsb/reports/2004-12-SARS_Memo_Final.pdf>.

Joint Recommendation: Improve Aeromedical Evacuation of Communicable Disease Casualties

Evaluation of Disease Transmission Risks during Aeromedical Evacuation

- *Perform comprehensive studies of the aeromedical evacuation process to minimize risks of disease transmission.* Infections passed to other casualties during medical evacuation flights by person-to-person, surface contact, or contaminated medical instruments or equipment must be controlled. Aeromedical evacuation will remain a key link to global power projection and mobility. Aeromedical evacuation enhancements in the last decade are largely responsible for the transformational changes in combat casualty care supporting a small but effective forward deployed medical support structure. The use of the Army Forward Surgical Teams, the Navy Forward Resuscitative Surgery System, and the Air Force Small Portable Expeditionary Aeromedical Rapid Response Team, and the reconfiguring of aircraft, staff, and equipment to provide critical medical care in flight have revolutionized expeditionary medical support for the warfighter. Aeromedical evacuation remains one of the greatest challenges while moving potentially infectious casualties. Limited air filtration and circulation, low humidity, low cabin pressure, and close contact between passengers all raise the risk for person-to-person transmission by both respiratory droplets and blood or body fluids. Several biocontainment "modules" exist for the single patient with a highly contagious infectious disease, such as Ebola or smallpox, but the logistics system is not available for multiple patients.

Enhanced Tracking of Casualties Aeromedically Evacuated from the Theater

- *Develop tools and processes to enhance casualty tracking on aeromedical evacuation flights and upon return to the Unites States.* These improvements should make the existing U.S. Transportation Command (TRANSCOM) aeromedical evacuation tracking system, TRANSCOM Regulating and Command & Control Evacuation System (TRAC2ES), database available for prompt queries by public health disease investigators, and the system should be enhanced to collect data on all passengers. Due to their occupational exposure, healthcare workers are at the highest risk of infection. Infection control, personal protection, and vigorous hand washing are regularly emphasized to minimize transmission of infections but are difficult in transit. The aeromedical evacuation system has established protocols for transporting casualties with known communicable diseases, but largely accomplishes this by dedicating an entire airframe to move a very small number of infectious cases. Since disease transmission may occur if a service member is unknowingly incubating an infection, such as influenza, CCHF, SARS, or *A. baumannii*, it will be crucial to identify all other service members who may have been exposed during the flight. This effort should be done in conjunction with a similar effort in the commercial airline industry, because many service members travel on commercial airlines within the short incubation period of many of these infections. Flight manifests are a critical part of contact tracing when an infectious person travels on a commercial aircraft, but they are not currently available in an electronic format in either the commercial or military

sectors. Once in the United States, DOD could utilize Radio Frequency Identification Technology (RFID) to track service personnel movement. An RFID tag is a small object that can be attached to or incorporated into a person, animal, or product, and is already used by DOD to track supplies and equipment. This would allow DOD healthcare personnel to keep track of and quickly locate service personnel who might have been exposed or are at risk of infecting others with an infectious disease. Such an effort would obviously have to take into consideration the need for operational security, but such data security issues can be easily addressed.

United States Southern Command (SOUTHCOM)

The SOUTHCOM AOR includes several countries where low-intensity conflict has been ongoing for many years. Current U.S. military involvement does not include large numbers of service members, but travel distance from fixed medical facilities can be great, and service members may need to be self sufficient for prolonged periods of time. Logistical support for such missions can be minimal, but exposure to disease-carrying insect vectors can be prolonged during the humanitarian assistance operations common in the AOR.

Good military order and discipline is not as much the issue in SOUTHCOM as is the need to improvise solutions when the full logistical support tail that accompanies large troop movements is lacking. Service members often must be skilled in more than one primary area, and creative thinking to extemporaneously and quickly manage difficulties is a requirement for success. The more preventive measures that can be designed into the gear at a service member's disposal, the more likely these measures will be used. The SOUTHCOM region faces a number of important health threats, including malaria, yellow fever, and dengue fever, which can and will affect combat operations. Military doctors and service members need to be prepared to combat these health threats, which often include infections from disease-carrying mosquitoes.

Case Study VI—Malaria and Force Protection

Malaria has been an important health threat to military operations for centuries and continues to be an issue for SOUTHCOM forces. In humans, malaria is caused by a one-celled parasite called plasmodium, transmitted by the female Anopheles mosquito. It appears to have lived "in the guts of reptiles" and—like many other disease-causing microbes—to have moved into humans around the time that organized agriculture began, 10,000-20,000 years ago.[86] Other forms of plasmodia still live in birds, reptiles, rodents, and nonhuman primates.

Only certain species of mosquitoes of the Anopheles genus, and only females of those species, transmit malaria. Female Anopheles pick up the parasite from infected people when they bite to obtain blood needed to nurture their eggs. Inside the mosquito, the parasites go through a life-cycle change and enter the stage that is infective to humans and migrate to the mosquito's salivary glands. When the mosquito bites again, the parasites pass into the blood of the person being bitten. Transfusion of infected blood can also spread malaria, which is why all potential blood donors are screened to see if they have been in a malaria-infested area.

Plasmodia have a complex life cycle, reproducing sexually inside mosquitoes and asexually inside both human red blood cells and the human liver. At one stage of their

[86] John Reader, *Africa: Biography of a Continent* (New York: Vintage Books, 1997), 244.

life cycle, they nest deep within the human liver, which is one key reason why malarial infections can be difficult to detect and treat.

Malaria has probably killed more people than any other disease in history. Today it is endemic—high levels of infection are permanent—in more than 90 countries. Approximately 40 percent of the world's population live in areas where malaria is transmitted, resulting in 350-500 million acute cases of malaria a year and 1-3 million deaths a year.

Figure 13

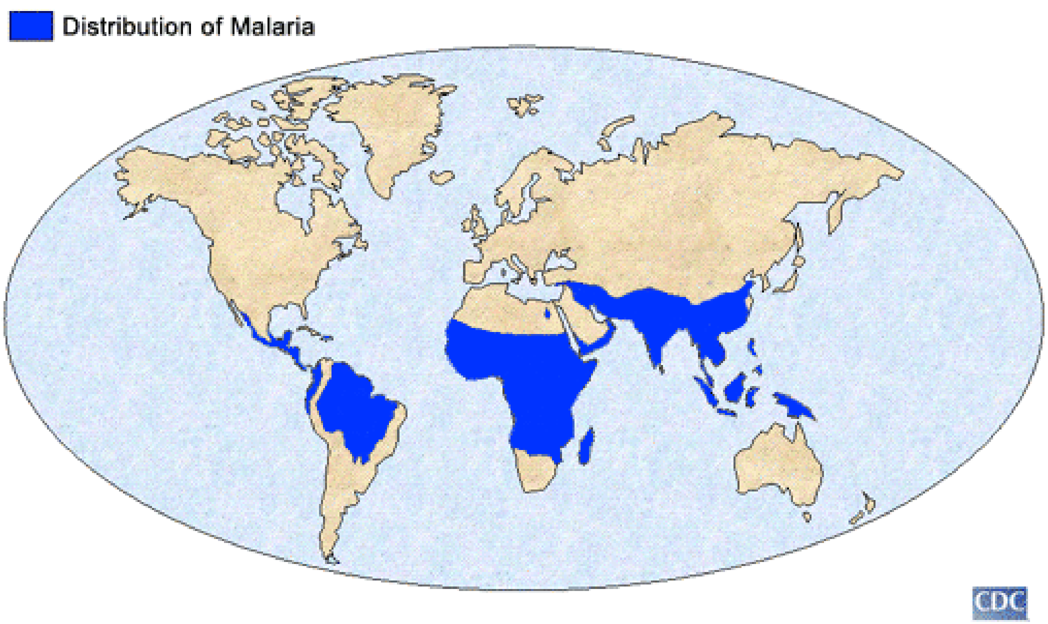

Figure 13 - Source: Centers for Disease Control and Prevention, "Geographic Distribution of Malaria," 23 April 2004. Available online at: <http://www.cdc.gov/malaria/distribution_epi/distribution.htm>.

Four types of malaria can cause infections in humans: *Plasmodium falciparum*, *Plasmodium ovale*, *Plasmodium malariae*, and *Plasmodium vivax*. *P. malariae* is the least common of the four types and both *P. vivax* and *P. ovale* can cause recurrent illness. *P. falciparum* is the most severe and life-threatening form of the disease and can cause organ failure and, in severe cases, can lead to cerebral malaria.

Most often, the first symptoms of malaria begin to appear about two weeks after a person is infected. The time period varies from 9 to 30 days, depending on the type of

Plasmodium infection. These symptoms are usually fever, headache, chills, and vomiting. If not treated promptly with effective medicine, malaria can kill by destroying red blood cells and by clogging the capillaries that carry blood to vital organs.

Many antimalarial drugs come from nature. The first and most famous is quinine, which scientists first isolated in 1820. Quinine is found in the bark of the Cinchona tree, which is native to certain mountainous areas of Peru. Local people, remnants of the Inca empire, drank teas made with this bark to combat fevers, and Spanish colonial officials began to use and write about it in the mid-17th century. Scientists recently determined that quinine kills *P. falciparum* by disrupting its food vacuoles, and the other three types of malaria by killing the parasites at the stage of asexual reproduction.[87] By the late 19th century, physicians and researchers had documented that quinine can also work as an effective prophylaxis, keeping people safe from malaria.

Several important antimalarial compounds have been synthesized de novo, including chloroquine and primaquine, developed as part of the U.S. Army drug screening program during World War II, and mefloquine, developed in collaboration between the U.S. Army, WHO, and Hoffman-LaRoche, Inc.[88] Several promising new compounds are in the final stages of testing, but further development is hampered by resource constraints.

The only major new malaria drug in the past 30 years is artemisinin, a chemical derived from one particular type of wormwood plant.[89] Chinese scientists rediscovered this agent in the late 1960s, when Chinese dictator Mao Zedong instructed them to use ancient herbal pharmacopoeia to find an antimalaria drug that could help North Vietnamese and Viet Cong soldiers then fighting the Americans and South Vietnamese.[90] Virtually all artemisinin in the world today comes from plants grown in China and Vietnam. Efforts to grow it in India, Brazil and other countries have failed. The plants prosper there, but for some reason—perhaps the soil or the weather—do not produce a consistent supply of the needed chemicals. Due to current worldwide shortages of artemisinin, in 2003 the Bill and Melinda Gates Foundation granted $42.6 million to develop a biotechnological technique that synthesizes artemisinin.[91]

Much research on malaria now focuses on genetics. Scientists, for example, have sequenced the genomes of the *P. vivax* and the Anopheles mosquito.[92] What practical results this will produce have yet to been seen.

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[87] Joel G. Hardman and Lee E. Limbird, eds. *Goodman & Gilman's The Pharmacological Basis of Therapeutics*, Ninth Edition (New York: McGraw-Hill, 1996), 979.
[88] Institute of Medicine, *Malaria, Obstacles and Opportunities* (National Academy Press, 1991), 150-153.
[89] Artemisinin is extracted from the dry leaves of the Chinese herb artemisia annua (qinghaosu, or sweet wormwood), which the Chinese used more than 2,000 years ago to control malaria.
[90] See Chinese Cooperative Research Group on Qinghaosu and Its Derivatives as Antimalarials, "Chemical Studies on Qinghaosu," *Journal of Traditional Chinese Medicine*, 1982, 2 (1): 3-8.
[91] Vincent JJ Martin, et. al., "Engineering a Mevalonate Pathway in Escherichia Coli for Production of Terpenoids," *Nature Biotechnology*, July 2003, vol. 21, no. 7, 796-802.
[92] See, for example, a series of articles on plasmodium genomics in the October 3, 2002 *Nature*, and a series of articles on the genome of the *Anopheles* mosquito in the 4 October 2002 issue of *Science.*

Recent and ongoing military missions indicate that a lack of attention to disease prevention continues to be an important but often overlooked issue. With adequate medical intelligence and strict discipline regarding mosquito control and use of prophylactic drugs, malaria, for example, should be a 100 percent preventable disease. Nonetheless, 131 U.S. Armed Forces personnel who served in Somalia during 1992-93 contracted malaria.[93] Marines contracted malaria in late 2003, after 133 were carried by helicopter into Liberia to protect U.S. diplomats during a civil war that threatened to dissolve into urban anarchy. No hostile action was ever directed at the Marines, yet more than one-third of them (53), some near death, had to be medically evacuated back to the ship due to malaria. Tests subsequently proved that none of the Marines had been taking their malaria medicine properly, including the 80 who were lucky enough not to get sick.[94] The perception that faulty generic drugs may have played a role was addressed, leaving the impression that there was failure by the command to supervise the use of malaria countermeasures, and failure by medics to assure that the command was supervising.

The wars in Afghanistan and Iraq, currently the highest priority for U.S. military planners, are recent examples of how the occurrence of disease and lack of discipline can affect military operations on foreign soil. One study of 725 Rangers who served in Afghanistan from June to September 2002 discovered that five percent became infected with malaria during their tour. [95] Interviews revealed that 48 percent of the Rangers did not take their prophylactic medicine, and 71 percent did not use insect repellant. Furthermore, 59 percent did not continue to take medicine after leaving malaria-infested areas, which is essential to eliminate any possibility of infection.

Because of side effects, whether real or imagined, troops often resist taking drugs, such as those that provide protection against malaria. During World War II, many U.S. troops serving in the Pacific did not take antimalarial medicines because their skin often turned yellow and there were rumors that they would become impotent. Today, many warfighters resist malaria prophylaxis because side effects—still not well understood—can include psychoses and seizures.[96]

One of the key threats to force protection and health in combat operations in malarial endemic regions is that drug-resistant *Plasmodium* strains are widespread. Coupled with an increasing number of mosquitoes that are insecticide-resistant, malarial infections have a significant tendency to affect combat operations in SOUTHCOM regions.

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[93] Centers for Disease Control and Prevention, “Malaria Among U.S. Military Personnel Returning From Somalia, 1993,” *Morbidity and Mortality Weekly Report*, 16 July 1993, 42(27), 524-526. Available online at: <http://wonder.cdc.gov/wonder/PrevGuid/m0021173/m0021173.asp>.

[94] “Officials Say Malarial Marines Didn’t Take Medication Properly,” *N.Y. Times*, 5 December 2003, A 27.

[95] S. Russ, et al., “An Outbreak of Malaria in U.S. Army Rangers Returning From Afghanistan,” *Journal of the American Medical Association*, 12 January 2005, 293, no. 2.

[96] See, for example, DOD, Armed Forces Epidemiological Board, “Armed Forces Epidemiological Board (AFEB) Select Subcommittee to Develop Mefloquine Study Options,” 21 May 2004.

Joint Recommendation: Develop Improved Combat Uniform Insect Repellant

- *Identify promising insect repellants to provide long-term uniform protection.* Military logistics planners should enhance the capacity of personal protective equipment to protect from vector-borne diseases. Future uniform modifications should improve upon the current loosely enforced requirement for each warfighter to periodically spray their uniform with permethrin to repel insects. Ideal repellant characteristics would include long term bonding to uniform fabric that resists being washed away when uniforms are laundered. Such efforts usually become a low priority during times of increased operational tempo, and are therefore neglected during the acute combat phases when warfighters depend on such protection the most. Such a capability is of added import to service members who are involved in peacekeeping or humanitarian assistance operations.

United States Special Operations Command (SOCOM) and Transportation Command (TRANSCOM)

SOCOM and TRANSCOM have unique worldwide responsibilities that raise distinct vulnerabilities to emerging infectious diseases. Both commands support missions of the geographic combatant commands in addition to their own unique missions.

U.S. Special Operations Forces (SOF) are particularly mobile throughout the world and may be required to travel to geographic locations with dangerous and unknown disease threats. Even though attached medical support prepares for known infectious disease threats, it is impossible to fully predict what health threats SOF may encounter.

TRANSCOM provides airlift and sealift of cargo and personnel around the world. Airlift assets are essential tools to support the worldwide projection of U.S. military power. These assets will be called upon to move military and civilian personnel during an infectious disease outbreak, such as influenza or SARS. Transportation from an area of increased risk, such as from Asia during the SARS epidemic, calls for the utmost precautions to prevent contributing to the international spread of an emerging infectious disease.

Such precautions were developed to support the movement of a U.S. citizen with suspected SARS from Vietnam. Infectious disease experts from both civilian and military agencies developed interim guidance for the air medical transport of SARS patients to support this patient movement.[97] The current problem centers around what steps must be taken to routinely disinfect or decontaminate an airframe that may have inadvertently transported someone who is incubating a disease or has such mild symptoms that the disease is unrecognized.

It is important for both SOCOM and TRANSCOM to coordinate and work in conjunction with regional combatant commands in infectious disease preparation and response. These commands operate in many geographical regions and are thus susceptible to multiple disease threats, including *A. baumannii*, leishmaniasis, Crimean-Congo hemorrhagic fever, malaria, SARS, and pandemic influenza.

[97] Centers for Disease Control and Prevention, "Guidance for Air Medical Transport for SARS Patients," 3 May 2005. Available online at: <http://www.cdc.gov/ncidod/sars/airtransport-sarspatients.htm>.

Strategic Recommendations for Worldwide Force Protection

Complex and changing threat conditions require proactive, anticipatory consideration of force protection requirements. These requirements will vary with changes in combat settings and tactics, enemy threats, and geographic environments. Military medical and combat casualty care experts must carefully but quickly consider the likely consequences for warfighters of any of these variations, alter existing force protection techniques, and develop new processes to maintain and enhance the combat forces.

Strategic recommendations from recent experiences in urban warfare and low-intensity conflict build upon those already described. They include:

- more in-depth evaluation and mitigation of environmental threats before troops enter an area;
- better monitoring and tracking of troops within the theater and, after leaving, their ongoing health status and changing vulnerabilities;
- more proactive measures to protect service members from environmental and disease threats and from each other when a contagious disease threat surfaces;
- more advanced diagnostic and treatment modalities that consider the threat environment and the in-theater force structure.

A theme of these recommendations is the need to take advantage of digital and wireless technology in force protection. Service member exposure depends on tracking their locations, and nothing short of fully entering the electronic age will address most of the surveillance needs cited above.

Environmental Surveillance and Mitigation

The geographic and climatic environment has long been the greatest noncombatant threat to the warfighter. Heat and cold, lack of water, sun, and insect vectors of infectious diseases will continue to require the highest degree of attention by military planners and medical and environmental experts. More and more information about local environments is available from commercial satellites, and more detailed disease vector threat information can be obtained by monitoring the disease burden in the local populations.

Remote Sensing of Environmental Threats

- *Link known environmental (terrain, vegetation, rainfall) and population data (urban vs. rural) to identify high-risk areas for transmission of leishmaniasis, malaria, dengue, and other vector-borne diseases of military operational importance.* Remote sensing of environmental threats is especially important in preventing disease in troops operating in Iraq. The actual disease prevalence in Iraq should be determined

in collaboration with the Iraq Ministry of Health, and joint vector control efforts should be undertaken to reduce the burden of disease in Iraqi citizens and in coalition military. Known and possible environmental threats will then guide force placement and prevention countermeasures in the initial phase of combat operations, and will identify the types of specialists required to further define and reduce threats, such as entomology teams to eliminate mosquito or sand fly breeding sites, or air or soil contamination sampling teams to identify toxic industrial chemicals that must be avoided.

Improve Environmental Sampling and Surveillance

- *Fast-track the development of molecular-based assays for environmental samples.* Proper management of potentially infected casualties requires all casualties to be managed as if they are infected until clinical test results are negative, a process that takes 3 to 6 days. The Air Force, for example, has established protocols at one deployed location that require all high-risk combat casualties to be managed as if they are infected with *A. baumannii* until they have been proven to be infection-free by laboratory cultures. Current environmental sampling and culturing methodologies may miss *A. baumannii*: they often fail to detect the organism in soil and water samples. Basing infection-control practices on negative environmental results using laboratory tests designed for clinical specimens may provide a false sense of security. In-theater field diagnostic technology should be developed rapidly to accurately detect *A. baumannii* in soil, water, and surface samples from equipment and skin. This will permit realistic, risk-based infection-control practices that are based on injury severity, location of in-theater care, presence or absence of the pathogen in the environment, and exposure to other sources of infection to be linked to in-theater and CONUS-based clinical surveillance results. Environmental surfaces in aeromedical evacuation aircraft should be sampled and tested before and after all medical evacuation flights, and careful monitoring of patients and medical personnel after flights should be done routinely to detect if transmission may be occurring in flight.

Surveillance and Management

Military decisionmakers require rapid situational awareness to warn them of a changing threat environment so they may evaluate potential courses of action, implement their decisions, and monitor outcomes so decisions may be modified as circumstances change. Effective disease surveillance systems allow the most timely and accurate assessment of the impact of environmental and infectious threats on combat troops. These systems generate data from a variety of sources that must be fused, mined, and analyzed to generate timely, actionable information upon which effective courses of action may be developed by medical personnel and line commanders.

Operational decisions will be made based on available data. Unknown or undefined disease threats can lead to wide-ranging and burdensome countermeasures, such as excessive personal protective equipment, personnel movement restrictions, isolation, and quarantine. As additional information becomes available, these countermeasures may be

safely relaxed to a degree. The sooner that actionable information is collected, analyzed, and presented to decisionmakers, the quicker operational restraints that were imposed to protect from disease threats can be reduced.

Improved Tracking of Service Members

- *Fast track the development and deployment of data-capture systems that allow real-time visibility of service members as they move around the world.* Such a system would provide real-time, accurate, location data so that each service member's exposure risk could be quickly determined, whether to an environmental disease threat or to another service member who may have been exposed and be at risk for transmitting an infection. A proof of concept pilot project that supports prompt contact tracing for disease investigation would use technology that is currently available, for example, RFID. This technology could quickly give DOD a system to track personnel coming out of theater and capture their movement to their home stations in the United States.

Enhanced Warfighter Disease Surveillance

- *Enhance and merge disease surveillance systems with other data sources so diseases acquired in theater may be detected and tracked once the warfighter returns home.* Until the data-capture system is developed, disease surveillance systems must include the ability to track warfighters from their home station to the theater and back to their home stations, must include their geographic location, and must support electronic capture of clinical disease data short of an actual laboratory diagnosis in-theater. For example, if a soldier is diagnosed after return to his home station with cutaneous leishmaniasis, the surveillance system should allow rapid identification of all other service members who were in the same geographic area in the same time period so these personnel and their medical providers can be notified of the increased likelihood that they could be infected. Since many of the combatants are guard and reserve members, the system must be able to reach those who return to inactive guard or reserve status once they demobilize.

Aggressive Infection Control Cohorting, Isolation, and Quarantine

- Aggressive infection control, isolation, and quarantine are especially important in the case of highly communicable diseases, including influenza viruses and some hemorrhagic fever viruses. *Infection-control procedures in-theater should be improved by cohorting persons at risk.* This should include a complete evaluation of patient and staff cohorting procedures to provide for the best infection control possible in field conditions and in fixed medical facilities, and should lead to policies and procedures that implement the practices to best protect injured service members and medical staff, given operational tempo limitations. Strict infection control is difficult and costly at all levels of care. It requires gowns and gloves for each and every person who comes into contact with the individual, and sinks for good hand washing near the bedside. In deployed settings, a common compromise in place of the

U.S. standard of private isolation rooms might be to cohort, or group, these patients in one ward, large room, or area of the field hospital or hospital ship. With strict infection-control procedures, this arrangement protects healthcare workers and provides reasonable protection for other patients in the facility, though it does not protect these service members from each other.

Policies to Support Appropriate In-Theater Use of Antibiotics

- *Develop policies to prevent misuse of the only antibiotic effective against multi-drug resistant bacteria.* While prophylaxis with broad spectrum antibiotics is a well proven measure in preventing wound infections from common bacteria that are found on the skin,[98] unnecessary use of Primaxin (imipenem/cilastatin) promotes antibiotic resistance in *A. baumannii*, for example, which is known to rapidly develop resistance in the presence of antibiotics. Prophylactic antibiotic administration should be limited to those antibiotics used to treat the usual bacterial causes of wound infections. Infectious disease experts have developed policy guidelines for in-theater use of antibiotics, but implementation has been hampered by inadequate supplies of the lower cost, first-line antibiotics that are less likely to contribute to antibiotic resistance.

Development of a Tri-service Antibiotic Susceptibility Surveillance System

- *Develop a DOD/VA surveillance system to collect and disseminate antibiotic susceptibility information.* Antibiotic resistance patterns detected should be linked to both the patient from whom they are collected and to the geographic source of the organism so prompt force health protection countermeasures may be developed and implemented. The current lack of such a system limits collection and dissemination of this information to each individual military MTF.

In-Theater Joint Disease Investigation Expertise

- *Military disease management experts should be available in-theater to provide surveillance and analysis expertise as soon as disease early warning systems detect an anomaly.* Each service has specialized teams to perform such analysis and response,[99] but these teams are largely staffed and deployed according to service-specific doctrine rather than theater-wide needs. Administrative barriers prevent quick redeployment of personnel and laboratory equipment within theater to respond to outbreaks. A true joint team of disease experts and diagnostic laboratory equipment should be developed to cross service and geographic boundaries and be truly responsive to the needs of the Joint Task Force Surgeon.

[98] David Burris, et al., editors, *Emergency War Surgery*, Third United States Revision, (Washington, DC: The Borden Institute, 2004), 103.
[99] The U.S. Army Theater Area Medical Laboratory, the U.S. Navy Forward Deployed Laboratory, the U.S. Air Force Theater Epidemiology Team.

Clinical Diagnosis and Treatment

Diseases caused or complicated by emerging infectious pathogens often require novel treatment regimens as more is learned about their disease course and transmission to others. Doctors must use available medications to treat these conditions and often choose antibiotic or antiviral treatments that are not in widespread use, because many organisms develop resistance to medications that are used commonly. These medications, when available, are often those that have more dangerous side effects or are in short supply. Occasionally treatments for rare conditions use medications that have never been approved by the Food and Drug Administration (FDA), since such approval requires rigorous trials in many patients to prove effectiveness and safety. These drugs must be administered under special administrative rules called Investigational New Drug protocols, and require that much additional paperwork be collected and reported to the FDA. Current treatment options are greatly limited for the conditions of military operational importance described in this paper, *A. baumannii*, Crimean-Congo hemorrhagic fever, and *Leishmania* infections.

The difficulties encountered in treating emerging infections require the best possible diagnostic technology so treatments can be expeditiously and efficiently targeted. A presumptive diagnosis is first made on the basis of clinical signs and symptoms, and the infectious diseases known to be present in the geographic location. Laboratory diagnostic testing is often necessarily to identify the cause of an infection early in its course and to provide the most appropriate treatment regimen.

Recent advances in molecular diagnostics can provide genetic fingerprinting of organisms so military medical experts know not only the pathogens causing a particular disease, but the antibiotics to which it is susceptible. As more genetic information is obtained about different strains of pathogens, it will be possible to identify common geographic sources and even patterns of virulence. This additional information will greatly enhance the military physician's ability to treat these service members, and will enhance the capabilities of military disease investigators as they track persons exposed to a contagious disease.

Improve Clinical Surveillance of Combat Casualties

- *Comprehensive tracking and disease surveillance should be undertaken on all injured warfighters after they depart from the theater.* In-depth disease investigation by in-theater clinical testing should become part of the standard procedures for military actions in Iraq and Afghanistan. As long as rapid diagnostic technology is not in place, wound and skin cultures of high-risk casualties should become a routine part of entering the air evacuation system <u>until infections are under control</u>. Currently, wound and skin cultures for *A. baumannii* are collected upon arrival at Landstuhl Regional Medical Center in Germany, but initial results are not available for 72 hours, and antibiotic resistance patterns require another 72 hours. Results from cultures could provide line and medical decisionmakers with important data to help identify injured service members needing aggressive surgical, antibiotic, and

rehabilitative treatment. Timely results will allow military physicians to quickly respond to changing patterns of infection, and improve outcomes and return-to-duty rates.

Develop a Topical Field Antibiotic or Improved Field Wound Dressing

- *Fast-track the development of a topically applied field antibiotic/protectant dressing.* Such a powder or spray could be used at the earliest levels of care, and could even be carried by warfighters or combat medics to be applied in the field at the time of injury, especially if combat actions prevent prompt evacuation and treatment. Characteristics of such an antibiotic or bandage would include topical application by spray or powder, rapid passage through intact skin and necrotic tissue so it immediately exerts its antibacterial effect without depending on blood supply, and effectiveness against all pathogens likely to be encountered—bacteria normally found on the skin and organisms found in soil and water—effectiveness against infection in adjacent living tissue, rapid metabolization, and rapid elimination from the body without side effects. This agent should be easy to store in field conditions and readily available in sufficient quantities. It should also be one to which pathogens will not quickly develop resistance.[100] A controlled-release formulation, where antibiotics are incorporated into biodegradable polymers designed to release sustained drug concentrations in wounds, may add protection for many days, a useful characteristic when medical treatment resources in-theater and aeromedical evacuation out of the theater are limited.[101]

[100] Konrad Hell, "Characteristics of the Ideal Antibiotic for Prevention of Wound Sepsis Among Military Forces in the Field," *Reviews of Infectious Diseases*, 1991, 13 (Suppl 2): S164-169.
[101] Elliot Jacob and Jean Setterstrom, "Infection in War Wounds: Experience in Recent Military Conflicts and Future Considerations," *Military Medicine*, June 1989, 154 (6): 311-315.

Historical Perspective

Military leaders have struggled with disease for millennia, before any understanding of the human body, before discovery of pathogens, before the development of antibiotics to treat infections, and before the availability of the diagnostics and treatment capabilities we have come to expect today.

Operational dilemmas faced in the past, consideration of courses of action, and ingenuity demonstrated in the face of uncertainly are a reminder that the predicament of emerging infections should not be thought of as overwhelming. Leaders should instead recognize the importance of continuously seeking opportunities to improve force protection practices. This requires proactive consideration of innovative steps to monitor and improve combat casualty prevention and treatment, of which history provides multiple examples.

Importance of describing symptoms, the course of a disease, and its patterns of transmission

Peloponnesian War (431-404 B.C.) The first disease investigator may have been Thucydides (471-400 B.C.), who used the best diagnostic technology available—his powers of observation. His eye-witness account of the plague at Athens has a detailed clinical presentation of signs and symptoms and the course of the disease over several weeks. He describes transmissibility by noting that "the birds and animals which feed on human flesh, although many bodies were lying unburied, either never came near them, or died if they touched them."[102]

Military operations in a resource-constrained environment call for improvised solutions

Siege of Turin (1537) Ambroïse Paré first gained fame as an army surgeon. He struggled with the standard treatment for gunshot wounds, cautery by pouring boiling oil into the wounds. One day while treating large numbers of combat casualties, Paré ran out of boiling oil, and said, "I was forced, that I might not leave (the wounds) undressed, to apply a digestive made of the yolk of an egg, oil of roses, and turpentine." The next day he unexpectedly found these casualties free from pain, well rested, and their wounds uninflamed.[103]

Importance of understanding the local operational environment to protect forces from diseases

Spanish-American War Colonel Theodore Roosevelt wrote of the havoc that poor sanitation, vile food, and swarms of mosquitoes were wreaking on the American Army in Cuba. When he received impossible recommendations from the War Department, he

[102] Logan Clendening, *Source Book of Medical History* (New York: Dover Publications, 1942), 27.
[103] Ibid., 192.

complained that the War Department "unfortunately knew nothing of the country nor of the circumstances of the Army."

Importance of trusted communication of operation advice from the medical officer to the commander

Revolutionary War General George Washington made and changed his command judgments based on staff advice. His initial operational order against smallpox inoculation in 1775 was based on advice from Dr. Benjamin Church, a prominent Boston physician who served as Washington's Chief Physician until he was accused of treason.[104] William Shippen, a Philadelphia land owner trusted by Washington, was later appointed Director General, and provided what appeared to be more appropriate operational advice.[105] He later advised Washington to variolate the Continental Army against smallpox while they were in garrison and could be isolated from other soldiers, so person-to-person transmission of smallpox was greatly reduced, and the death rate was minimal.

Spanish-American War "No matter how many recommendations were made…, only those recommendations were carried out which the commanding officer desired." As Dr. Walter Reed expressed it, "The Army Medical Corps has received a black eye because of the neglect and incompetence of men who did not really belong to it."[106]

Leaders must develop and enforce procedures and policies to protect forces

Revolutionary War Poorly disciplined troops neither built adequate latrines and sanitary facilities nor used the available ones, with the result that in short order they contaminated their water supply. The lesson of strictly enforcing regulations on the use of sanitary facilities has had to be relearned in every war.[107]

How perception of inequitable treatment quickly leads to civil disturbance

Mexican Revolution of 1910 The use of quarantine to control disease transmission has had a jaundiced history in the United States. Any involuntary restriction of movement infringes on personal liberty, as any disobedient child can attest. Efforts to restrict movement to control disease have been associated with racist and anti-immigration movements.

[104] John Duffy, *The Healers: A History of American Medicine* (Chicago: University of Chicago Press, 1976), 81.
[105] Mary Gillett, *The Army Medical Department: 1775-1818* (Washington, DC: US Army Center of Military History, 1981).
[106] Ralph Major, *Fatal Partners: War and Disease* (New York: Doubleday, Doran, and Company, 1941), 197.
[107] Duffy, 79.

Conclusion

Newly emerging and reemerging infectious diseases, coupled with increasing resistance of both pathogens and vectors, pose a risk to U.S. national security because they threaten the military's ability to protect its forces. Infectious diseases associated with urban warfare or low-intensity conflict, coupled with the challenges of providing treatment for combat casualties and nonbattle injuries and illnesses, will continue to strain the abilities of military medicine to preserve and restore the fighting strength of U.S. military forces. DOD must cultivate a culture of innovation in force protection and develop a Joint cadre of military medical and combat casualty care experts who will follow the shifting patterns of illnesses and injuries, both during and between conflicts, and bring the full weight of advanced research and development to bear on rapidly solving these threats to health and national security. These experts must understand the culture and environment of military operations, so that their advice to the line commander is relevant and realistic. They should not encourage or allow their commander to think that the medics have all the answers and are responsible for the outcomes. This responsibility rests with the unit commander.

The emergence of urban warfare and low-intensity conflict as the focus for military operations in OEF/OIF, taken together with the emergence of new enemy tactics, is leading to transformation of U.S. and coalition military tactics. Transformation of military casualty-care processes is leading to improved surgical and medical care. There is a critical need to examine and respond to the impact on society of infectious disease challenges introduced when warfighters return home for definitive treatment and rehabilitation. Such challenges will continue as the U.S. military reduces its presence overseas and relies on rapid deployment of forces.

The recommendations for special monitoring and management of injured and potentially infectious warfighters may seem aggressive. The systematic actions necessary to address these complex challenges, however, require reexamination of deployed force structure, targeted advanced technology research, and improved coordination and information sharing among DOD, the Veterans Health Administration, and the civilian healthcare systems. Perhaps the greatest challenge to implementing many of these recommendations is the difficulty of working across organizational cultures. Military medical officers and line commanders must understand their mutual responsibilities to protect the fighting force. Military experts must work with their counterparts in the civilian community, at the Federal, state, and local levels, and in the private sector.

Technological advances have multiplied the effectiveness of warfighters, allowing a smaller force to be much more effective. Military medical and line leaders must create an environment in which developing problems may be identified and addressed before they result in combat ineffectiveness. Future line and medical leaders must be developed in such a forward-leaning setting.

Colonel Ron Bellamy, one of the preeminent experts in combat casualty care, pointed out more than 20 years ago that there is an ongoing need to keep an open mind toward unorthodox and even outlandishly futuristic proposals for combat casualty care.[108] Such seemingly unorthodox thinking must include operational planning and policymaking, thereby allowing DOD to undergo a transformation that provides the best possible force protection for warfighters of today and tomorrow. After combat operations were well underway in World War II, military strategic planners finally realized that a well-coordinated and successfully executed military campaign demands a mastery of diseases of operational importance.[109] It should not be necessary to relearn this lesson.

[108] R.F. Bellamy, "The Causes of Death in Conventional Land Warfare: Implications for Combat Casualty Care Research," *Military Medicine,* 1984, 149: 55-62.
[109] Robert Bwire, *Bugs in Armor: A Tale of Malaria and Soldiering*, (Lincoln, Nebraska: iUniverse.com, Inc., 2001), 155.